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BAYER PFLANZENSCHUTZ-NACHRICHTEN

English edition

No. 2, 1953

PUBLISHED BY THE BAYER PLANT PROTECTION DEPARTMENT
LEVERKUSEN AND HÖFCHEN

CONTENTS

Page

1. Dr. H. Mühlmann:
   Control of Red Mites in Viniculture in Rhine Hesse 73

2. Prof. Dr. A. Jamalainen:
   The Significance of Cereal Seed Dressing in Finland 80

3. Dr. F. Kersting:
   Control of Butterbur on Meadows and Pastures . . 83

4. Dr. Hedwig Hirschmann:
   Control of Leaf Nematodes with "Systox" 90

5. Josef Schmit:
   Tests to control the cherry maggot with phosphoric ester preparations 113

6. Dr. Ir. A. Soenen:
   The Tortrix Moths of Our Fruit Trees 117

7. Dr. G. Unterstenhöfer:
   Field Tests with the Systemic Insecticide "Systox" against the Bean Aphid *(Doralis fabae Scop.)* on Horse Beans *(Vicia faba* L.) 121

8. Dipl.-Landwirt W. Meyer-Bahlburg:
   Economy of the Cockchafer Control 130

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FARBENFABRIKEN BAYER
AKTIENGESELLSCHAFT
Department for Plant Protection
LEVERKUSEN

Control of Red Mites in Viniculture in Rhine Hesse*

By Dr. H. Mühlmann

Although it has developed into a matter of course for fruit-growers and gardeners to take control measures against the red mite, it is still taking the vine-growers a long time to realize that another member has joined the ranks of important parasites.

At a time when most people had not even thought of this pest, attentive vine-growers in the Bingen district observed changes in their vineyards for which they could not account. The result was that steps were taken in 1947 in the village of Ockenheim to determine whether the grape leaf louse was the cause of this infestation. The result of the investigation was negative and because no other parasites could be found, the vine-growers were content to attribute these changes to a "vein" in the soil. It was not until 1950 that the real cause of the damage was discovered, namely the red mite, and in 1951 certain vine-growers added "E 605" conc. to each of the Peronospora sprays applied during the control period. On the strength of this measure the infestation appeared to recede although the parasite could not be eradicated to a sufficient extent. This was realized in the following autumn when the top leaves were again heavily colonized and the shoots were populated with innumerable winter eggs.

In the spring of 1952 it was intended to arrange control tests against the red mite in the village of Ockenheim, but just at that time it was found that this parasite was appearing everywhere, and not just in the district of Bingen. It had in fact spread its infestation to Oppenheim itself although it had not caused any damage during the previous year and in fact had not even been detected. Control measures were taken everywhere and the impression was gained that the red mite had died out. It was established in all cases that the red mite concerned was exclusively *Paratetranychus pilosus* C. and F. Towards the end of June shoots apparently infested by red mites were again submitted to the Institute. It was seen, however, that this time, and in fact in all reports later made by the vine-growers, the mites concerned were of the *Epitetranychus althaeae* v. H. species — once again exclusively. It is characteristic of this species that the mites not only appear on vines and other cultures but also on such weeds as hawkbit, lesser bindweed, thistles etc. As September was drawing to a close, however, the presence of *P. pilosus* once again became apparent everywhere and to a certain extent the infestation was so heavy that here and there every single leaf had been attacked despite many weeks of bad weather (84 mm/m² in September).

An interesting example of a phenomenon characteristic of viniculture is described below. During a visit to the test plots in Ockenheim a few weeks before the vintage it was noticed that the grapes in the uniformly infested vine-yards were considerably underdeveloped in some cases. According to statements

* Excerpt from a lecture held on October 23rd, 1952, at the meeting of the study group 'Rebschutzmittel-Prüfung" in Veitshöchheim.

made by the vine-growers concerned who, it may be said, were completely unprejudiced and keenly observant, these symptoms of lack of nourishment had, however, only appeared in places where the red mites had attacked in large swarms during the previous years. The underdevelopment of the Silvaner vine varieties may be attributed to the extraction of nutrition by this pest over a number of years.

In view of the urgency of the problem, control tests were carried out in Ockenheim, Dienheim and Oppenheim. The preparations sprayed were 0·03 % "E 605" conc., "E 605" conc. + 0·2 % wettable sulphur 80, 0·05 % "Systox" and a comparative agent (preparation X). At one place 0·15 % nicotine with an addition of a wetting agent was sprayed.

I. Ockenheimer Hang: size of the test area = 0·86 acres; age = 12 years. The plots were replicated five times.

First spray: April 24th. About 650 winter eggs were counted and of these 25 % were hatched; despite this the young leaves were, to a certain extent, already heavily colonized with mites.

Second spray: May 3rd. 10 days later; no repetition with "Systox"; 78 % of the eggs were hatched, although a part of the empty shells had apparently fallen; the percentage of eggs which had not hatched was therefore in reality already smaller.

Evaluation: May 7th. From each plot, leaves showing signs of infestation were counted under the binocular lens 15 with the naked eye. It was only in single cases that a dead mite was found on the vines left untreated.

	"E 605"		"E 605" + NS		"Systox"		Prep. X	
	living	dead	living	dead	living	dead	living	dead
absolute:	153	894	139	628	74	982	211	654
%:	14·6	85·4	18·1	81·9	7·0	93·0	24·3	75·7

The best results in this test were obtained with only one spray of "Systox". The effect of "E 605" was not so penetrative. The addition of wettable sulphur caused a slight reduction of 3·5 %, a value which is within the natural limits of error. In the case of the comparative preparation as compared with the other agents, the vines were distinctly backward in their growth following the first treatment (Photos 1 and 2). In order to avoid economical damage, this preparation was not used on a part of the plots for the second spray but instead "E 605" was applied.

Another interesting point about this test was that the plots belonged to two different vine-growers, namely Messrs. Jäger and Reckert, although there was no visual indication of it. When the results were evaluated it was particularly noticeable that the number of mites per leaf differed in each case, until it was later established that these differences must have been due to the treatment of the vines in the previous year. As we have already mentioned above, "E 605" was added to each of the six Peronospora sprays carried out in 1951; a concentration of 0·035 % was added to the first 2 sprays and 0·02 % to the other four. It is worth mentioning that this measure was taken only by Jäger, whereas Reckert only added "E 605" to the first 2 sprays. When the mites counted

per leaf from the plots of the two owners are compared, it is seen that on an average there were 21·8 mites per leaf on Reckert's property, whereas there were only 7·5 on Jäger's plots. The regular addition of "E 605" therefore had clearly reacted on the infestation of the following year.

II. Dienheimer Guldenmorgen: size of test area = 1·85 acres. The vineyard was divided into three square blocks of more or less the same size. The blocks were treated with "E 605", "Systox" and the preparation X respectively, and in the case of the last block, 8 rows (out of a total of 36) were treated with nicotine with the addition of a wetting agent.

First spray: April 25th and 26th. 52 % of the eggs were hatched and in certain cases up to 120 mites were counted per leaf.

First evaluation: May 5th. 25 leaves from each plot were counted.

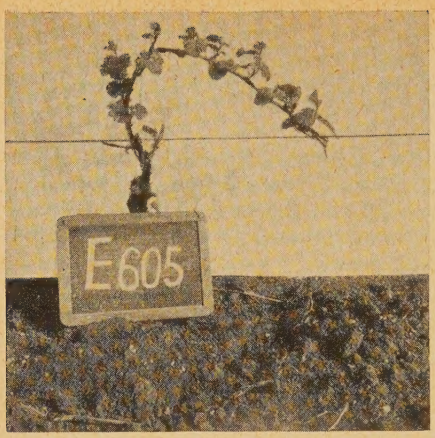
	"E 605"		"Systox"		Prep. X		Nicotine	
	living	dead	living	dead	living	dead	living	dead
absolute:	234	372	8	3	21	53	215	218
%:	38·7	61·3			28·3	71·7	49·6	50·4

Second spray: May 6th, 12 days later, but only with "E 605" and nicotine.

Second evaluation: May 9th.

	"E 605"		"Systox"		Prep. X		Nicotine	
	living	dead	living	dead	living	dead	living	dead
absolute:	66	129	3	2	33	1	116	146
%:	33·8	66·2					40·4	59·6

The fact that the acaricidal effect of "E 605" only produced an extermination of 66·2 % following two treatments was far from satisfactory. The single spray with "Systox" once again had a most penetrative effect and even 14 days afterwards there was still not a single freshly hatched red mite to be found. The noticeable point in connection with this preparation was the small number of mites found at both evaluations without a second spray having to be applied although it had been established before the treatment that the degree of infestation in all three plots was uniform. It is supposed that the poisoned mites had either migrated or had dropped off. This phenomenon, however, was not observed in Test I. The parasite appeared to react to the preparation X in a similar manner. A migration or dropping off in this case is highly probable because those vine rows treated with nicotine were only a part of the preparation X block and showed 27·8 mites per leaf, whereas following the treatment with the comparative preparation only 4·3 mites per leaf were counted. The growth of the vines was once again hindered by the effect of this agent although this time it was not so striking as in Test I, and two weeks later the number of mites had again increased.



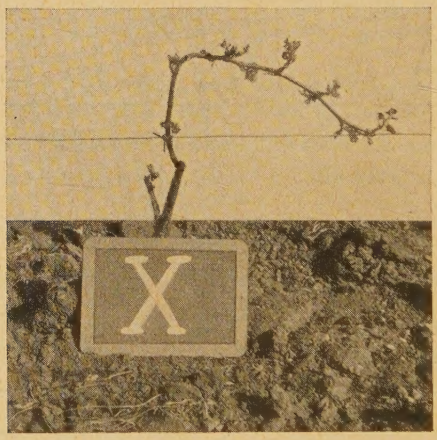


Fig. 1. Test 1: State of vine on May 7. (Photo by H. Jäger).

III. Oppenheimer Kette: size of the test area = approx. 0·13 acres. Age of the vineyard = 3 years. Three plots, all more or less of the same size, were treated with "E 605", "Systox" and the preparation X respectively.

First spray: April 23rd.

First evaluation: May 6th. 25 leaves per plot were counted.

	"E 605"		"Systox"		Preparation X	
	living	dead	living	dead	living	dead
absolute:	240	547	18	122	24	43
%:	30·5	69·5	12·9	87·1	35·8	64·2

The vines in the plot treated with the preparation X were not only backward in growth but also clearly showed leaf burnings, even though these were slight.

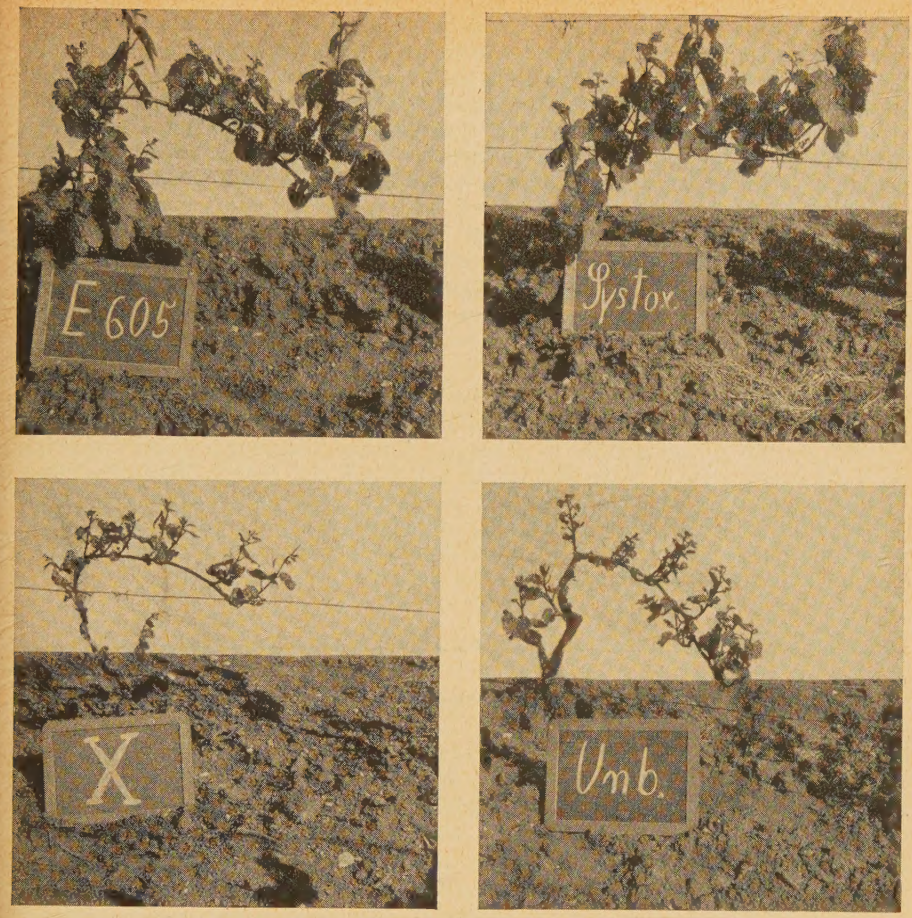


Fig. 2. Test 1: State of the vine on May 20. (Photo by H. Jäger).
(Abbreviation "Unb." in the bottom right-hand photo = untreated).

Second spray: May 6th, 14 days later, only with "E 605".

Second evaluation: May 10th. In the plot treated with "E 605" only two living mites were found out of 145 on 25 leaves, i. e. 98·7 % exterminated. With respect to the number of mites per leaf this is similar to the phenomena observed in Test II.

On comparing the results obtained from these three tests, it is seen that to an extent they differ considerably. The most pronounced difference is in the case of "E 605":

Test II 66·2 % killed
Test I 85·4 % killed
Test III 98·7 % killed.

In my opinion the only explanation for this great difference is that the interest shown for the sprays or the conscientiousness with which they were

carried out varied in each case. In Test II the sprays were applied by workers who performed their tasks without any thought for the test results or the yield. In Test I, the owner himself together with his son carried out the sprays, and in addition to his hope for a good yield, he was also very much interested in the result of the test, in spite of the fact that there was a tendency to regard the spraying as troublesome — even though necessary. The main reason for this was that other agricultural work was waiting to be done. In Test III we encountered an owner of a small vineyard, who put every effort imaginable into his work in order to increase the yield. The spraying was carried out so conscientiously that the upper and lower surfaces of every single leaf were wetted.

It was seen therefore that the agent which does not produce satisfactory results in one test has a most penetrative effect in the other, and set-backs which are occasionally brought to our notice with respect to "E 605" are mostly to be attributed to inexpert spraying.

Damages to vines resulting from the application of the preparation X were similar to those above. In those cases where the best results were obtained with "E 605", the vines displayed the most serious damage following intensive spraying with the preparation X. After the leaves had fallen, the growth-inhibitive effect of this preparation was so strong that the shoots were only weakly developed. These tests, however, were not finally completed until the end of November, when ten cut shoots were taken indiscriminately from each plot and counted bud for bud under the binocular lens for deposits of red winter eggs.

Test I:

	Control	"E 605"	"E 605" + wettable sulphur	"Systox"	Prep. X
examined nodes:	538	684	726	597	370
number of eggs found:	3,923	1,331	1,811	695	1,768
eggs per node:	7·3	1·9	2·4	1·1	4·8
calculated on the check = 100 % infestation:	100	26·0	32·9	15·1	65·8

The order of precedence with respect to the effect of the agents is therefore still the same as in spring following counts of mites still alive. The number of eggs on the untreated vines is relatively low and probably this is because the densely cultivated vineyard was again treated 4 times with "E 605" conc. (0·03 %) in addition to the usual sprays. A vineyard situated outside the test area and which had not been separately treated in spring showed an average of 40·6 eggs per node on 10 shoots.

Test II:

	"E 605"	"Systox"	Preparation X	nicotine
examined nodes:	150	164	153	138
number of eggs found:	10,787	5,027	5,661	7,693
eggs per node:	71·9	30·6	37·0	55·7

The inadequate spraying referred to above is again clearly reflected in the large number of eggs per node. The difference between the number of mites on a leaf treated with "E 605" and on a leaf treated with nicotine on the one hand, and between a "Systox" treated leaf and one sprayed with preparation X on the other hand, may also be recognized. During the course of the summer the "Guldenmorgen" was once again treated with "E 605" (0·015 %) by using the "Molekulator" of Messrs. Platz, Ludwigshafen.

Test III:

	"E 605"	"Systox"	Preparation X
examined nodes:	150	136	137
number of eggs found:	765	504	776
eggs per node:	5·1	3·7	5·7

Even in this test the order of precedence has remained the same as it was in spring. The differences, however, are considerably reduced following intensive spraying by the owner of the smaller vineyard. During the summer a single spray was carried out with "E 605" (0·03 %).

Summary

1. Two thorough sprays with "E 605" conc. (0·03 %) led to a completely successful control of the red mites.
2. The combination of "E 605" and wettable sulphur 80 (0·2 %) produced practically the same results as for "E 605" alone.
3. "Systox" (0·05 %) was just as acaricidally effective as "E 605". From an economical point of view it may be said that some progress has been made when considering that a single treatment is adequate. The poisoned mites apparently either fall off or migrate.
4. The mites appeared to react to the comparative preparation X in a similar manner. The effect was far behind that of "E 605" and "Systox", and furthermore the growth was seriously inhibited.
5. The effect of the applied nicotine (0·15 %) was unsatisfactory.
6. The results obtained in spring are to a large extent reflected again in the number of winter eggs laid.
7. Good results may only be obtained even with the best of agents provided the spraying work is carried out conscientiously and carefully.
8. Approximately 6,300 mites and 45,700 winter eggs were counted in order to arrive at these results.

The Significance of Cereal Seed Dressing in Finland

By Prof. Dr. E. A. Jamalainen,
Department for Plant Pathology, Agricultural Experimental Institute, Tikkurila (Finland)

In a very interesting article published in No. 1/2 of this series in 1951, Mag. agr. Olaf Nielsen reported on the significance of cereal seed dressing in Denmark based on the results of many years of experimental work. The results of cereal seed dressing tests carried out over a number of years were also recently published in Finland[1] and it would appear expedient to reproduce these results for the purpose of making comparisons of the significance of seed dressing in the various countries. Mag. agr. Antti Elomaa prepared the publication on behalf of the local experimental organization. The tests were carried out as local tests and on so-called permanent test fields in various districts of Finland as well as on behalf of the departments of the Agricultural Experimental Institute, at the Plant Breeding Institute, Tammisto and at regional experimental stations. The tests were arranged in accordance with the regulations of the Plant Pathological Department of the Agricultural Experimental Institute.

Concerning the methods adopted, it should be mentioned that the tests were carried out as ordinary field tests. The average size of the test areas was 20 sq. m., and each one consisted of 4—5 replications. The test seed was not artificially infected. Each preparation used for dressing contained mercury and in most cases they were dry seed dressing agents. For the dry dressing of rye, wheat and barley, 200 g of dressing agent were used per 100 kg of cereals whereas in the case of oats 300 g were applied per 100 kg. The tests embraced German, English, Dutch and Swedish as well as local preparations. Most of the tests were carried out with the German dry seed dressing "Ceresan". A summary of the dressing tests is given in the attached Tables 1 and 2. According to Table 2, the local tests produced a yield increase as follows: 86 % of the winter rye tests, 100 % of the winter wheat tests, 84 % of the barley tests, 98 % of the oats tests and 79 % of the spring wheat tests.

The most injurious plant disease on winter rye in Finland is mould (*Fusarium nivale* [Fr.] Ces.). In Finland, stripe smut (*Tuburcinia occulta* [Wallr.] Liro) is of no particular importance as a factor responsible for reducing the harvest. With respect to mould, very much valuable information is offered by the results of the dressing tests. The considerable yield increases of winter rye may be attributed to the preventive effect of the dressing on mould damage. In those years when the yield increases of winter rye were large as a result of dressing, the hibernation was correspondingly poor and mould appeared on a large scale. During the various years, the weather conditions have produced either favourable or unfavourable conditions for the appearance of mould. Whenever sowing was carried out early and the young seed developed well before the frost had set in, this seed was subjected to the damaging effects of mould. These injuries caused by mould were considerable even in those cases where there was a thick sheet of snow on non-frozen ground thus protecting the soil surface against winter frost. The conditions prevailing in spring also seriously influence the appearance of mould. When there is a heavy fall of snow which, due to

[1] Elomaa, A., Viljan peittauskokeiden tuloksia vuosilta 1928—1950 (Finnish). Summary: Results of cereal seed treatment experiments with disinfectant during the years 1928—1950. Reports of the State Agricultural Experimental Organisation in Finland, 226, p. 1 to 43, Helsinki, 1952.

cool weather, does not thaw very quickly in spring, the damage caused by mould may be great. Therefore in view of the conditions prevailing in Finland, mould can be regarded as the most important yield decreasing factor for winter rye during the hibernation period.

In the case of winter rye, the variation due to hibernation conditions was so great that e. g. in the two successive years 1947 and 1948, the yield increases in the local tests amounted to 3 % and 38 % respectively. In the winter of 1946/1947 the fall of snow was not so heavy as is normally the case and the permanent snow blanket did not appear until December with the result that the mould was not able to inflict serious damage. The hibernation therefore was good. On the other hand, as already mentioned above, a thick blanket of snow encourages mould injury. Both on the basis of the local tests as well as according to the tests results obtained at the experimental stations, it may be concluded that mould inflicts far greater damage in the heavy snow districts of central and eastern Finland than in the southern and western parts of that country.

It should be mentioned that according to the research work carried out by the Department for Plant Pathology at the Agricultural Experimental Institute, there are considerable differences in the degree of resistance to mould among the winter rye varieties cultivated in Finland. The most resistant are the Finnish varieties Toivo, Ensi and Greus and the variety Vjatka which originates from the Soviet Union. In districts where mould regularly inflicts injury on the crops, it is worthwhile cultivating those varieties which are relatively very resistant to mould. The varieties Oiva, Onni and Pekka, which among the Finnish varieties usually produce the best yields, are considerably more susceptible to mould and in view of this they are only suitable for cultivation in South and West Finland.

Based on relatively few dressing tests, the injuries caused to winter wheat by mould are to be regarded as being less serious than those on winter rye. It should be mentioned that the research work carried out by the Department for Plant Pathology at the Agricultural Experimental Institute has shown that at least all winter rye varieties generally grown in Finland at present are relatively resistant to mould. Stinking smut of wheat (*Tilletia tritici* [Bjerk.] Winter) is capable of causing general and at times heavy damage to winter wheat in Finland so that in several tests this disease was able to act as a yield reducing factor on untreated test plots. Detailed information on the appearance of plant diseases, particularly following local tests, could not be established.

The yield increases for spring wheat are due in the tests to the effect of the dressing agent against injuries caused by stinking smut (*T. tritici*) and snow mould of the seed (*Fusarium* sp.). The average yield increase obtained by dressing in the tests carried out at the experimental institutes and stations was less than that obtained in the local tests which shows that the seed used in the tests was not strongly infected either by stinking smut or by mould.

The fact that there was a really considerable increase in the barley yield in most cases may be attributed to the seed being infected by leaf stripe (*Helminthosporium gramineum* Rabenh.) and that the dressing agents were effective against this disease. This applied particularly to the tests recommended for permanent test fields which were chiefly carried out in North Finland. Furthermore the dressing was of significance as a measure taken against snow mould of the seed (*Fusarium* sp.) and against covered smut of barley (*Ustilago hordei* [Pers.] Lagerh.).

The increased yields in oats may be attributed first and foremost to the good effect of the soil or mould infestation of the seed (*Fusarium* sp.) and secondly to the effect on loose smut of oats (*Ustilago avenae* [Pers.] Jens.). Covered smut of oats (*U. levis* [Pers.] Kell. & Sw.) seldom occurs in Finland.

Table 1: **Summary of the yield increase obtained in dressing tests, expressed in per cent of the basic yield.**

	Local Tests		Permanent Test Fields		Experimental Institutes & Stations	
	No. of Tests	Yield Increase %	No. of Tests	Yield Increase %	No. of Tests	Yield Increase %
Winter rye	58	18·7	—	—	73	20·0
Winter wheat	11	4·9	—	—	24	6·7
Spring wheat	60	7·3	—	—	13	3·6
Barley	58	7·5	22	12·5	21	4·4
Oats	41	11·6	—	—	14	15·2

Table 2: **Break down of yield increases obtained by seed dressing into different size classes for various cereal varieties.**

Yield increase class kg/hectare	Winter rye		Winter wheat		Barley		Oats		Spring wheat	
	Test plots		Test plots		Test plots		Test plots		Test plots	
	No.	%	No.	%	No.	%	No.	%	No.	%
1000	3	4	—	—	—	—	—	—	—	—
501—1000	10	12	—	—	6	9	3	7	3	4
101—500	34	43	4	36	22	32	25	60	36	47
1—100	22	27	7	64	30	43	13	31	21	28
0	11	14	—	—	11	16	1	2	16	21
Total	80	100	11	100	69	100	42	100	76	100

The tests show that seed dressing in Finland produces really favourable results on all cereal varieties and that it is profitable. The yield increases are considerably greater in Finland than in Denmark where, according to the above-mentioned article of N i e l s e n , the average yield increases in all tests amounted to 100 kg for barley, 60 kg for oats, 90 kg for rye and 90 kg for wheat.

The dressing of cereals has become increasingly prevalent in Finland since the middle of the 1930's. However, it has not spread to the extent desired when it is considered that at the most only one third of all seed sown in Finland today is dressed. The main reason why dressing has not become so widespread in

Finland as e. g. in Denmark and Germany, is because relatively little is done in this country by means of machinery and again, unlike many other countries. there are no seed dressing stations in Finland. Because seed dressing is chiefly carried out in dressing drums, the labour question has proved to be an obstacle to the general application of this treatment.

Control of Butterbur on Meadows and Pastures

By Dr. F. Kersting, Pflanzenschutzamt, Münster in Westfalia

Butterbur (*Petasites officinalis* Mnch.) has become an extremely troublesome and injurious weed over extensive areas of meadow and pasture land, particularly in valleys and lowlands. Spreading from the banks of rivers and streams, the weed very quickly colonizes under suitable growing conditions on neighbouring grassland and, provided a check is not put to the propagation, dense clusters are formed within a very short time stretching over large areas. Fields completely overgrown by the weed are nowadays commonplace (Figure 1). The butterbur, with its broad leaves, overshadows the ground to such a great extent that the development of fodder plants growing underneath is more or less supressed. In most cases where butterbur has taken root, the turf is patchy (Figure 2) and only inferior quality grasses are able to grow on it.

Cattle do not particularly like butterbur as fodder, which means that its propagation can be indirectly promoted. It is only in cases of intensive grazing that the development of the weed is seriously impaired by cattle treading on it. Moreover, it is extremely difficult to harvest hay on meadows colonized by butterbur. The thick fleshy stems — if not completely dry when harvested — begin to rot quite easily, whereas the dry leaf surfaces crumble easily and can mostly be written off as a loss.

The plant is propagated not only by the abundant formation of seed on the imposing inflorescences in spring but also by the development of underground shoots on the rhizome which is sometimes 1·5 m long. Because these shoots are not easily accessible to direct control measures, all previous efforts made in this direction have been concentrated chiefly on preventing seed production and propagation as well as on weakening the plants. In certain districts there are still police regulations in force which stipulate the seasonal mowing of the inflorescences and the foliage. Apart from the fact that many farms do not comply with such regulations and that it is nowadays particularly difficult to see that they are carried out, the success of enforced measures has often proved to be unsatisfactory where suitable planning and management have not been initiated to aid the control programme.

Numerous examples taken from the experience of farmers repeatedly show that it is quite possible to crush the growth of the weed by joint mechanical and cultural measures. Wherever the impermeable layers of the soil can be broken through mechanically thus draining off all surface water, means that the plant is deprived of an important prerequisite for good development. Very often local conditions do not permit this. Frequent mowing of the foliage will prevent the plant from storing reserve materials in its underground organs for new shoots. Intensive grazing of the fields — if possible by putting out sheep to graze —

Figure 1. Pasture land completely overgrown with butterbur.

Figure 2. Foreground treated, with good turf, butterbur leaves removed at the rear, only single poor-quality and insufficiently developed grasses.

together with proper treatment and fertilization for the promotion of the culture plants will weaken the weed and finally bring about its extermination. Care should be taken, however, that seeds from other weed-infested areas are not carried over. In this connection it is pointed out that experience has shown that floods or irrigation can contribute considerably to butterbur colonization when water from infested areas -- even over large distances -- carries seeds of the weed with it.

Figure 3. Butterbur in blossom. Butterbur likes moisture and often grows on the edges of streams. It is propagated by seeds and root runners.

The above-mentioned control methods clearly indicate to what extent the control of butterbur must be regarded as a duty of the community if it is really to lead to permanent success. They also show, however, how difficult it is to get at the weed and from this it is seen that in many cases the necessary measures cannot be carried out at all according to plan or else only inadequately, due to local or farming conditions. This is confirmed by the extent of butterbur-infested areas still to be found in many places today. For this reason an attempt has also been made to utilize chemical weed killers in the control of butterbur.

The chlorates were the only ones among the early preparations which brought off reasonably good results. Apart from their high price, they have a disadvantage, however, of being most difficult to apply (too great a consumption of water) and furthermore no plants are able to grow in the treated soil for about 6 months afterwards. This means that the practical use of these preparations to control butterbur is extremely limited. Nevertheless, chlorates were frequently used in the field during the previous year.

When weed killers containing growth regulators were first introduced, it was soon found that butterbur is very resistant to 2,4 D salt preparations. Admittedly the growth of butterbur can be diminished by applying high concentrations of this agent and by repeated treatment thus limiting the intensity of the leaf development, but just the same it is only with difficulty that a satisfactory extermination can be attained, especially when taking into consideration the expenditure incurred. The MCPA agents, according to our experience, have proved to be inferior to the 2,4 D salts in their effect on the plant, whereas the 2,4 D ester preparations were found to be superior to the agents of the above-mentioned groups with respect to the exterminating effect and, when applied in large quantities, useful results were obtained even with a single treatment.

Shortly after these compounds were introduced, other preparations appeared on the market which, apart from the 2,4 D, contained another similar active

ingredient, briefly referred to as 2,4,5 T. These agents, which turned out to be particularly effective against such woody weeds as broom, were also tested for their suitability in the control of butterbur. The effect of the first treatments carried out in the summer of 1951, the result of which was seen in spring 1952, proved to be surprisingly favourable, and in fact appeared to be far better than that obtained with 2,4 D esters. The author has reported on this in another paper. This work has been systematically continued since spring 1952. The autumn evaluations based on extensive test series and a total of 110 single treatments are now available and permit an opinion to be given on the most important questions based on the test arrangement. The evaluation carried out by counting the weeds before the treatment and again in autumn is based on previous experience with respect to aftergrowth in the year following the treatment. When applying the same quantities, the results were more or less the same for the three 2,4 D / 2,4,5 T preparations tested. The differences in the success values of the single agents applied on the same area are within the limits of error.

The effect on the various test areas differs considerably in certain cases. This fact, which can also apply to the control of other weeds which are difficult to destroy, appears comprehensible when it is considered how complicated the mode of action of the compounds is and, on the other hand, how variable the living and growth conditions of the plants can be in different areas.

The approximate extermination percentages following the application of quantities between 4 and 10 litres and 4 and 10 kg per hectare (2·47 acres)* which are to be expected according to the results of our tests are given in the following table.

kg or litres of agent per hectare	4	5	6	7	8	9	10
% of exterminated butterbur plants	50—70	70—80	80—90	84—92	87—94	90—96	95—100

If an extermination of 80—90 % of the weed together with a permanent injury to the growth of the remaining weeds is assumed as the lowest limit for economically satisfactory results, then the minimum application of the agent required to attain this must have been approx. 6 litres or kg/hectare. When larger quantities of agent were applied, the increase in effect was less in proportion than that for increased quantities of agent up to 6 litres/hectare. According to the results available, farmers would also be recommended to apply 6—8 litres or kg/hectare in cases of heavy weed infestation.

Rucksack and horse-drawn sprayers were used in the tests we carried out, and it was found that both types of equipment are perfectly suitable. It is preferable to use rucksack sprayers (Fig. 4) when treating banks and slopes, edges of streams and nests of weeds, whereas the horse-drawn spraying equipment should be used for large areas. With respect to the required quantity of spray wash, it appears from previous tests, although not concluded, that good results can only be obtained when the broad leaves, which in many cases more or less cover each other, are fully wetted as far as this is possible. If this is done, it

* The quantities of liquid agent applied were calculated in litres per hectare and the paste in kg per hectare.

seems that it is only the applied quantity of agent per hectare which is important. Generally speaking, 400—800 litres of spray wash per hectare are sufficient. It was not definitely established to what extent the effect is dependent upon the size of the droplets.

When spraying large areas with horse-drawn apparatus, care should be taken that every inch of ground is covered, otherwise aftertreatments will be necessary. Seeing that the spray film dries very quickly and afterwards becomes invisible, it has always been found worthwhile when using horse-drawn sprayers to mark the paths taken by the sprayer so that they overlap each other, and when using rucksack sprayers to divide the area being treated into plots in order to ensure that the work is carried out satisfactorily. It would be expedient for

Figure 4. Controlling clusters of butterbur with rucksack sprayer.

the practical application of these agents if the film spray on the plants could be made visible by adding a colour or some other compound.

The success of the treatment was fully ensured when spraying was carried out in moist, warm weather and when the sun was not shining too brightly. The best time is in the morning and evening when there is no wind. Rainfall on the day of treatment can impair the effect, but any rain following spraying has no influence on the results. At the time of spraying there should be sufficient moisture in the soil to enable an intensive growth of the weeds.

When the application conditions were favourable, the full effect was obtained as soon as the greater part of the leaves had developed, in other words from the 10th of May onwards. The effect, however, appears to recede steadily from the beginning of July, and it would, therefore, be advisable to increase the amount of preparation applied in the July and August sprayings as the year goes on, so that by the middle of August the quantity sprayed is 1/3 more than the standard quantity suggested. Following the end of August the effect was unsatisfactory.

In cases where the foliage of the weeds was first mown and the control was carried out against the aftergrowth, the effect of the agent was not helped to any positive extent. Approximately 6—8 weeks after the treatment the leaves

Figure 5. Butterbur control on a heavily weed-infested pasture. Left: sprayed with 8 litres of "Tributon" per hectare. Right: untreated.

Figure 6. Treated plots strictly defined from the weed stock showing well developed grass growth 8 weeks following the application of the spray.

are withered and dead and the areas appear to be free from butterbur (Fig. 5). The border lines of the treated areas can be clearly recognized from a considerable distance (Fig. 6). It is surprising to observe how clearly the grass turf on the treated areas develops again. Without doubt, the good biological ripeness of the soil under the shade of the butterbur contributes considerably to this.

Single weeds which survive the control or develop from the rhizomes are mostly backward in their growth. In many cases these are plants whose foliage was so well covered during the treatment that the active ingredient applied was not sufficient to exterminate them. In other cases the foliage of the plants dies off but the rhizome is still so active that new plants are able to shoot up from single buds. Therefore every effort should be made to exterminate weeds left over following treatment. This is best done by means of cultural measures, and in special cases it may be necessary to carry out a further treatment with chemical agents.

There should be no doubts about the economy of treating large areas which are completely overgrown with butterbur or areas where only single clusters occur. Depending upon the intensity of the weed infestation the expenditure per hectare is between DM 70—100. There is no danger to culture plants on areas thickly colonized with butterbur even when relatively high quantities of control agent are applied, because there are hardly any growing there. It is quite a different matter, however, in the case of butterbur plants which grow singly over large areas, but mostly it should be possible to exterminate these without using chemical agents. Should it be necessary, however, to use these agents, farmers will have to put up with a loss of clover and other fodder plants as well as a temporary stoppage to the growth of the grasses, although it does not take long to make up again for this damage. White clover in particular has proved to be very resistant and recovers very quickly or else recolonizes. In such cases care should be taken, however, to avoid unnecessary damage and this also applies to the drifting of spray mist onto neighbouring cultures.

With the development of the 2,4 D / 2,4,5 T mixed preparations, farmers have been given a further aid to defend their grassland effectively against butterbur infestation where mechanical and cultural measures are not sufficient.

Considering the keen interest shown everywhere in the tests and exhibitive controls carried out, it is to be expected that the farmers concerned will very soon adopt these new methods to their advantage. Wherever local conditions permit it, the control work should be carried out as far as possible on a community scale.

It is to be hoped that continued attention to the problem, particularly taking into consideration the hints given by R a d e m a c h e r for the control of meadow saffron, will lead to cheaper and more favourable control possibilities.

Control of Leaf Nematodes with "Systox"

By Dr. Hedwig Hirschmann, Zoological Institute, Erlangen.

Contents

Methods and materials

Comments on the classification of leaf nematodes

1. Effect of "Systox" on the fern or strawberry eelworms *Aphelenchoides fragariae* (Ritzema Bos 1891) Christie 1932.
   a) Behaviour of *Aphelenchoides fragariae* towards continuous toxic action.
   b) Behaviour towards short "Systox" action.
   c) Behaviour towards repeated toxic action.
   d) Spray tests on nematode-infested fern plants *(Pteris).*
2. Effect of "Systox" on the chrysanthemum nematode *Aphelenchoides ritzema-bosi* (Schwarz 1912) Steiner 1932.
   a) Behaviour of the nematodes towards continuous toxic action.
   b) Behaviour towards short action.
   c) Behaviour towards repeated action.
   d) Spray tests on chrysanthemum infested with *Aphelenchoides ritzema-bosi.*
3. The conduction of "Systox" in the plant.
4. Effect of "Systox" on other nematode species.
5. Mode of action of "Systox" in the nematode body and in the plant.
6. Hints on practical control.
7. Summary.

During recent years the German chemist Schrader developed a new systemic insecticide with the designation 8169 which was recently put on the market under the trade-name "Systox" by the Farbenfabriken Bayer, Leverkusen. From a chemical point of view, this excellent systemic agent closely resembles Pestox III which, although discovered in Germany, was marketed by an English firm. Pestox III, however, in contrast to "'Systox", is an octamethyl tetramide.

The systemically effective organic phosphorous compounds are highly capable of infiltrating and penetrating through plant tissues. They are absorbed by the plant through the roots, leaves and shoots and then spread over the vascular system of the plant without damaging it. Because of these properties, such agents guarantee a successful control of all sucking pests, including those which parasitize in the tissues of the plants themselves, and which can only with difficulty, or even not at all, be exterminated by the usual and more ectotherapeutically effective spray and dust agents.

The new preparation "Systox" has rapidly established itself in plant protection and has proved to be of good lasting effect producing excellent results particularly against such sucking pests as red mites, aphids, woolly aphids, scale insects, grape leaf lice and strawberry tarsonemid mites. Success, therefore, appeared certain also for an application against leaf nematodes parasitizing in the leaf tissues of cultures and which belong to the nematodes of the genus *Aphelenchoides* Fischer 1894. These nematodes frequently occur as an infestation in nurseries and are capable of completely destroying a plant stock.

Bosse (1952) recently reported on the application of "Systox" as a watering agent against nematodes in chrysanthemums and begonia. He carried out a successful control of the chrysanthemum nematodes under favourable conditions. Good control results had already been obtained by Goffart (1950) and Sachs (1950, 1952) with "E 605", which also possesses a certain "penetrating" effect against fern and chrysanthemum nematodes.

The control tests carried out on the same *Aphelenchoides* species with the systemically effective preparation "Systox" were of particular interest from a comparative point of view. The mode of action of the agent was tested in exact model experiments. The information already gained was supplemented from the results of spray tests on infested plants.

Methods and Materials

For all the model tests, the poison was diluted to fixed concentrations with distilled water. The check tests were carried out in spring water and the temperature prevailing during the tests was 19—21° C. Small glass jars (1 cm in diameter, 0·8 cm high), sealed with corks, were used in moist chambers as experimental vessels in order to prevent a material loss of the preparation through its volatility with water vapour. Preliminary tests had shown that when "Systox" is left on hollow-ground slides in moist chambers for 2 days at room temperature, it evaporates without leaving behind any perceptible residue. Checks at low temperatures (10—13° C) produced a far lower volatility. Great importance was attached to clean and, as far as possible, germ-free work; all the vessels and instruments were sterilized in boiling water before use, the distilled water used as solvent was again brought to the boil and filtered hot, and only fresh toxic solutions were used for the various tests.

The infested plant material was finely cut up and placed in water. The nematodes which soon began to swim about quite freely were washed several times in water and then transferred to "Systox" solutions of the following concentrations: 0·05 %, 0·025 %, 0·017 %, 0·005 %, 0·001 % and 0·0001 %. A record was kept daily of the number of dead worms. The infested plant material *(Pteris, Chrysanthemum* etc.) was provided by the Erlangen and Fürth nurseries.

The spray tests were carried out on potted plants at various temperatures and humidities *(Pteris* 23—25° C, *Chrysanthemum* 18—20° C), because if outdoor plants had been used a new infestation may have occurred which could not be controlled.

Comments on the Classification of Leaf Nematodes

The nematode genus *Aphelenchoides* Fischer 1894 contains a number of closely related species which are difficult to distinguish morphologically. On the one hand American authors attempted to put together the majority of plant-damaging *Aphelenchoides* species — also including *Aphelenchoides olesistus,* known as the fern nematode, and the chrysanthemum nematode *Aphelenchoides ritzema-bosi* — into one group, namely *Aphelenchoides fragariae* which causes the cauliflower disease on strawberries, whereas other circles insist upon the species being classified independently. On the basis of detailed variation statistics within this group, Junges (1938) was able to separate distinctly the species *Aphelenchoides olesistus* Ritzema Bos 1893 from *Aphelenchoides ritzema-bosi* (Schwarz 1912) Steiner 1932. Recently, however, Franklin (1950) and Allen (1952) have proved with the aid of much investigation material, that the fern nematode *Aphelenchoides olesistus* is identical with the strawberry eelworm *Aphelenchoides fragariae* (Ritzema Bos 1891) Christie 1932 which was incompletely described by Ritzema Bos in 1891. Furthermore Allen confirmed that there is every justification in classifying the chrysanthemum nematode *Aphelenchoides ritzema-bosi* in a species of its own because he stated in his descriptions of both species that the latter can easily be distinguished morphologically from *Aphelenchoides fragariae.* I fully agree with the opinion of Allen on the basis of my own investigations.

These systematic comments are of significance for the practical control insofar as the nematodes examined in the following are two species which can be easily distinguished from one another — on the one hand the fern or strawberry eelworm *Aphelenchoides fragariae,* on the other hand the chrysanthemum nematode *Aphelenchoides ritzema-bosi.* Although both species have many host plants

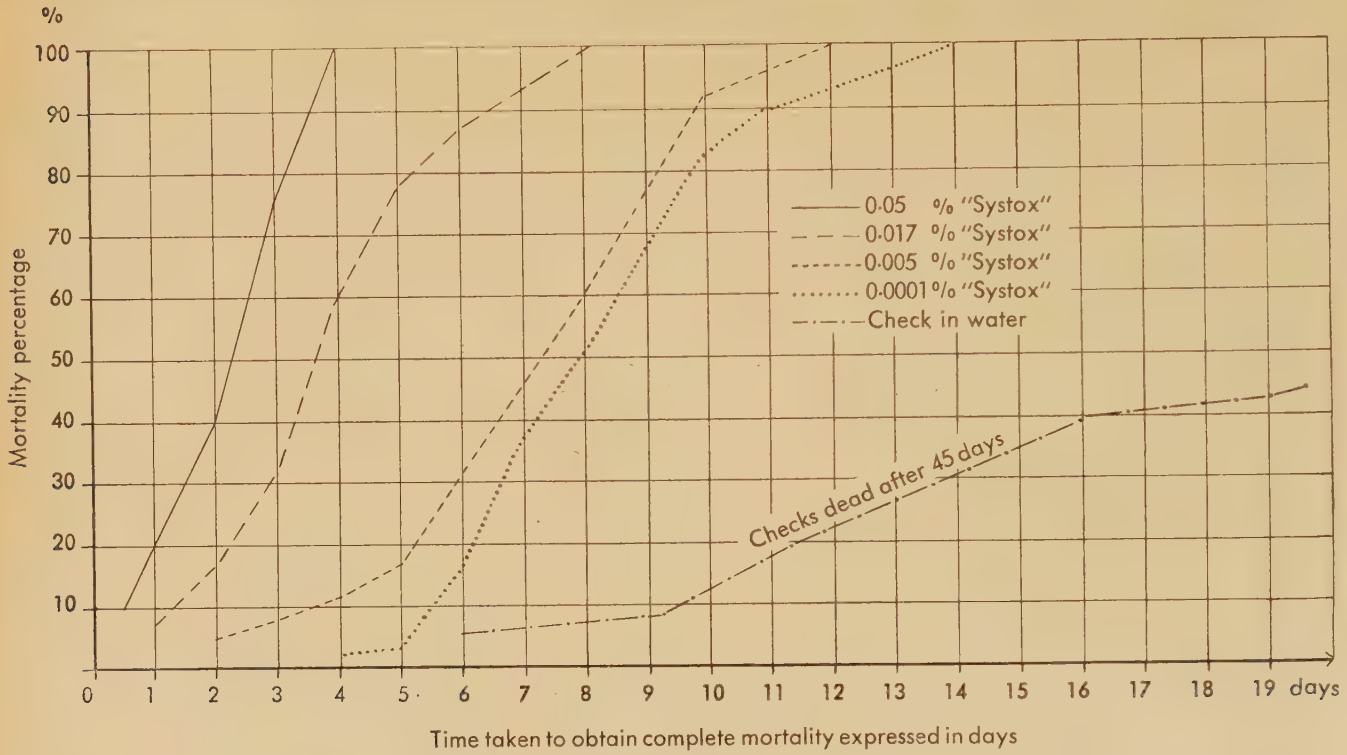


Fig. 1. Behaviour of *Aphelenchoides fragariae* with continuous toxic action

in common, they do differ considerably in the choice of their hosts and in other biological characteristics, e. g. life-span, resistance to poison specific to the species, rate of nutrition absorbtion etc. Apart from the knowledge of the peculiarities of the pest, many other important factors, such as the vegetation stage and water content of the plant, atmospheric temperature and relative humidity, water content of the soil etc., play a decisive part in the success of the control.

1. Effect of "Systox" on the Fern and Strawberry Eelworm *Aphelenchoides fragariae*

a) Behaviour of the nematodes towards continuous toxic action (Fig. 1)

Nematode-infested *Pteris* plants whose pinnae were considerably interspersed with brown spots clearly limited by the leaf veins were used as test material.

The nematodes which were swimming about freely in water in large snaky lines were sorted out into four test groups each containing 100 animals and placed in 0·05 %, 0·017 %, 0·005 % and 0·0001 % solutions of "Systox" respectively. At the beginning the nematodes were very lively but soon afterwards the toxic effect made itself noticeable by convulsive symptoms of paralysis. The worms sank to the bottom of the experimental vessels and some of them lay there curled up, whereas others, although trembling heavily, attempted weak swimming movements which quickly became cramped and finally developed into complete immobility. When touched gently, the curled and bunched up animals merely responded with weak twitches of the anterior and posterior. It was only when they were dead that the nematodes straightened out again and it was perceived that the posterior of the male was slightly curled up. Table 1 shows the course of movement inhibition until complete immobility for 0·05 %, 0·017 %, 0·005 % and 0·0001 % concentrations of "Systox". The first symptoms of paralysis became perceptible after 45 minutes in a 0·05 % toxic solution, and after 2 hours 15 minutes all the worms were lying bunched up and paralysed at the bottom of the vessel. In the 0·017 % solution of "Systox", the paralysis again set in after 45 minutes, but was not complete until after 2 hours 45 minutes. The first curled up animals in a 0·005 % solution were not observed until after a period of one hour and it took 5 hours 15 minutes until they were completely inhibited in their movements. The effect of a 0·0001 % toxic solution was very much weaker. Admittedly, the first symptoms of cramps were noticed in this case after 1½ hours but 50 % of the nematodes were still swimming about quite freely on the following day and it was not until the second day that all the animals were paralysed.

In comparison with "E 605" conc., the nematodes showed a far greater sensitivity to "Systox". Whereas the first symptoms of paralysis set in after 45 minutes for 0·05 % "Systox", 45 minutes for 0·017 % "Sytox", 1 hour for 0·005 % "Systox" and 1½ hours for 0·0001 % "Systox", these symptoms did not become noticeable in the same concentrations of "E 605" conc. until after 1½ hours, 3 hours, 4 hours and 9½ hours respectively. Even the occurrence of 100 % paralysis was 60—90 minutes earlier in the case of "Systox" than that for the corresponding concentration of "E 605" conc. A striking factor in the effect of the various "Systox" concentrations was that there was very little temporal difference in the commencement of paralysis.

In the fundamental tests the behaviour of the nematodes towards continuous toxic action was studied (Fig. 1). Four test series using 50 animals in each were arranged for the "Systox" concentrations 0·05, 0·025, 0·017, 0·005, 0·001 and

Table 1: **Course of Movement Inhibition** for *Aphelenchoides fragariae*.
100 nematodes were used for each concentration

Time	0·05% "Systox"	0·017% "Systox"	0·005% "Systox"	0·0001% "Systox"
12·00	All nematodes swimming freely	All nematodes swimming freely	All nematodes swimming freely	All nematodes swimming freely
12·45	10% curled up on the bottom of experimental vessel	10% curled up on the bottom of experimental vessel		
13·00	40% curled up	20% curled up	8% curled up	
13·15	80% curled up	50% curled up	15% curled up	
13·30		70% curled up		4% curled up
13·45	95% curled up			
14·00			80% curled up	
14·15	100% curled up but still signs of lively movements	98% curled up		
14·30			84% curled up	
14·45		100% curled up but still signs of lively movements		
15·00	All nematodes paralysed to a considerable extent		88% curled up	10% curled up
15·30			94% curled up	
15·45	All nematodes inactive	All nematodes paralysed to a considerable extent		
16·15			96% curled up	
16·30		All worms inactive		
17·15			100% curled up but still signs of lively movements	
	Slight movements again after 22 hours, although the first dead worms already detectable	Slight movements again after 21 hours, first dead nematodes already detectable	Slight movements again after 20 hours	50% curled up after 22 hours 100% curled up after 42 hours

0·0001 %. Depending upon the concentration of the poison, 100 % mortality of the worms was obtained after 4 to 14 days. An average of 75 % of the nematodes in a 0·05 % solution of "Systox" died after 3 days, and one day later the remainder had died. With the 0·025 % concentration, 75 % died on the fourth day and 100 % mortality was obtained on the 5th day. It took 5 days before 75 % of the nematodes had died in a 0·017 % toxic solution and a 100 % mortality was obtained on the 8th day of the test, whereas these values were not obtained until the 11th and 12th day respectively for the 0·005 and 0·001 % "Systox" and on the 14th day for the 0·0001 % concentration.

The last animals succumbed after 45 days in the checks carried out in water.

After a long period in "Systox", the curled animals assumed a glassy appearance and were transparent. The old males and females were the first to succumb to the poison followed later by young males and lastly the young females.

In comparison with "E 605" conc. (Sachs 1952), "Systox" proved to be much more effective in all concentrations applied continuously on *Aphelenchoides fragariae*. Whereas it took 7 to 40 days to obtain a 100 % mortality with 0·05—0·0001 % washes of "E 605" conc., this result was obtained after 4—14 days with the same concentrations of "Systox". It was perceptible in these tests that the various concentrations of "Systox" speedily produce a 100 % mortality within a period of 10 days, as compared with 33 days for "E 605" conc.

b) *Behaviour of Aphelenchoides fragariae towards short-term action of "Systox" (Fig. 2)*

The influence of the effectiveness of "Systox" concentrations by possible decomposition in the plant itself, as well as by other such factors as water content of the plant, speed of liquid absorption, transpiration etc. was imitated in model tests, in which the nematodes were left for a short period in the toxic solution.

The "Systox" concentrations applied were 0·05, 0·025, 0·017, 0·005 and 0·001 %. Three series of tests were carried out for each solution using 50 worms in each test. Each 50 nematodes were transferred from the applied concentration to water after 1, 2 and 3 days respectively.

The time taken to obtain complete mortality in these tests was far longer than that taken in the fundamental tests. A 100 % mortality was obtained on the 21st day at the earliest and on the 28th day of the test at the latest. The effect was more or less the same within the concentration range of 0·05—0·017 % "Systox". Nematodes subjected to the effect of poison for one day put up the longest resistance before being killed, whereas worms subjected to a toxic action for three days died within the shortest period. Following a one day application of poison, 50 % of the nematodes died after 11—13 days, 75 % after 17—20 days and 100 % after 26 days. After being subjected to a toxic action for two days, 50 % of the worms had died on the 6th day at the earliest and on the 9th day at the latest, 75 % on the 15—18th day and 100 % on the 24th day. Following a three day toxic action, the first animals succumbed within 2—5 days, and after a period of 11—14 days, 75 % were dead; 100 % mortality was obtained on the 21st day. A 100 % mortality was obtained on the 24th day at the earliest and 28th day of the test at the latest with the "Systox" concentrations 0·005 and 0·001 %. Once again we found that there is very little difference between the effects of the various concentrations and it is in fact more emphatic than in the continuous tests.

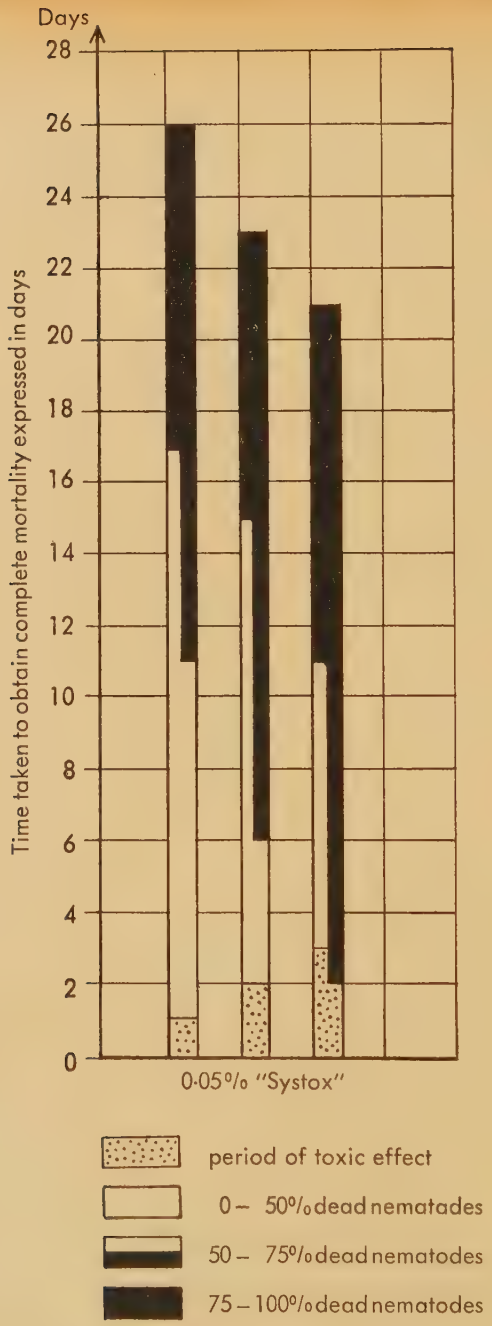


Fig. 2. Behaviour of *Aphelenchoides fragariae* towards short-term action of 0·05% "Systox" solution.

The apparent ability of the worms to recover after being subjected to a short-term action of "Systox" is much greater than that of the animals treated with "E 605" conc. The latter succumbed to "E 605" conc. 8 to 13 days earlier than the nematodes treated with "Systox".

The nematodes subjected to 0·05—0·001 % concentrations of "Systox" soon began to show signs of lively movements after being transferred to water. 20 % of the worms were again swimming about freely after 24 hours in water and the other nematodes were moving about uninterruptedly on the bottom of the vessel. It was not until 4 to 8 days later that the nematodes again became rigid and gradually died. Even 15 % of the nematodes subjected to 2 days of toxic action were able to swim again after transfer to water. Although 50 % of the nematodes had already died in the poison when subjected to a 3 day treatment, the remainder recuperated so well in water that 18 days had passed before a 100 % mortality was obtained.

It was only in short term tests with 0·005 and 0·001 % concentrations of "E 605" conc. that S a c h s (1952) was able to establish an ability of the animals to recuperate as far as the swimming stage. In these tests, 25 % of the animals were able to swim again after being subjected to a one day treatment in a 0·005 % wash, and in the case of the test in a 0·001 % wash, 100 % of the animals recuperated and were able to swim freely. In contrast to "Systox", a reoccurrence of paralysis was only observed in isolated cases in the 0·005 % series and on the 5th day in the 0·001 % series with "E 605" conc.

c) Behaviour of Aphelenchoides fragariae towards repeated toxic action (Fig. 3)

In view of the great ability of the worms to recuperate after being subjected to a short-term action of "Systox", the next series of tests were arranged in order to examine whether the killing of the nematodes could be accelerated by repeating the toxic dosage after a short period of time.

The same concentrations were used as for the short-term action. 50 animals from each concentration were transferred to water after lying in the toxic solution for 1, 2 and 3 days respectively. On the 5th day, all the worms were again subjected to the same toxic concentrations for 24 hours and then returned to water.

The animals which recuperated so well in water following the first dosage of poison became paralysed so quickly after a repeated dosage that a 100 % mortality was obtained on the 9th day for 0·05 and 0·017 % concentrations of "Systox" (Fig. 3). 90 % of the worms which had firstly been subjected to the poison for 2 to 3 days died as early as the 7th day, and with the 0·005 and 0·001 % concentrations of "Systox" a 100 % mortality was obtained on the 12th day at the latest. A repeated dosage of both 0·05—0·017 % "Systox" as well as 0·005—0·001 % "Systox" resulted in a spontaneous 100 % mortality of the nematodes without any difference in the period of the primary toxic action.

Similar times to effect complete mortality were obtained with repeated dosages of "E 605" conc.

It was only with a 0·05 % concentration of "Systox" that a fatal effect on the eggs of the fern nematodes was established; in all the lower concentrations the larvae emerged even in the face of a continuous toxic action.

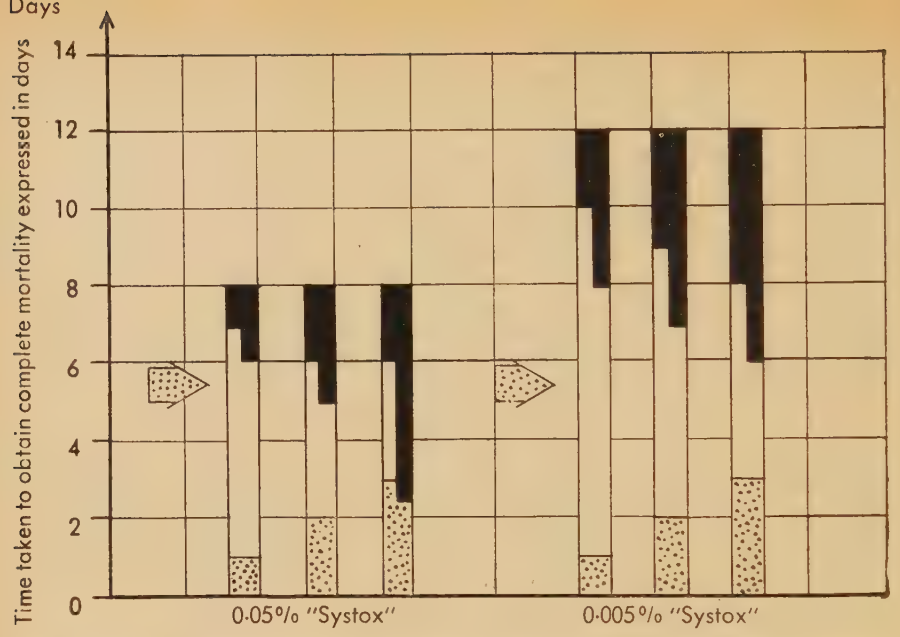


Fig. 3. Behaviour of *Aphelenchoides fragariae* towards repeated action of 0·05 and 0·005% solutions of "Systox".

d) Spray tests on nematode-diseased fern plants (Pteris)

The results of the model tests gave rise to high expectations for a good effect in the control tests on the living plants.

A single spray or watering of the infested plants, according to this, should be successful when the effective concentration remains constant in the plants for at least 24—48 hours (even the eggs of *Aphelenchoides fragariae* are no longer capable of developing after being subjected to high concentrations!). As shown in the following tests, these conditions apparently can only be realized for "Systox" under extremely favourable circumstances (Bosse 1952), and it is advisable to spray and water the diseased plants thoroughly on a number of occasions at short intervals in order to effect complete control of the parasites.

Three diseased potted *Pteris* plants were kept under somewhat dry conditions in a hothouse at 24° C and each was sprayed with 300 c.c. of a 0·05 % solution of "Systox" until the upper and lower surfaces of the leaves were completely wetted. Two of the plants were checked for nematodes at regular short intervals. On the days shortly after the spraying, all the worms isolated from the leaves were considerably curled and furthermore a number of old animals and larvae were found to be dead, so that on the whole the population density receded somewhat. However, after 14 days, there was again an abundance of young animals on the plants and only some of the old animals were curled up. After a further period of 14 days, the nematodes were again perfectly healthy and those isolated from the leaves all swam around in a lively manner. Under these conditions, therefore, a single spray was not adequate for the effective "Systox" concentration to remain active in the plant for a sufficiently long period and only a part of the worms succumbed to the poison.

The treatment of the third fern plant was continued in the meantime, and three dosages of 300 c.c. of 0·05 % "Systox" solution were applied at intervals of 3 days, care being taken that the leaves were completely wetted. Following the second spray, the infestation density receded from 570 nematodes per sq.cm to 320 per sq.cm.; only a few of the animals ware able to recuperate to the swimming stage whereas all the others were curled to a considerable extent. Following the third spray, the population density again decreased to 150 nematodes per sq.cm. and the leaf tissue was densly interspersed with dead worms; no more leaf nematodes were to be found in a young pinna heavily covered with brown spots. Following the fourth spray, only dead nematodes and a few heavily curled up worms (50 per sq.cm.) were found in both young as well as old infested leaves. In the check carried out after 14 days on four heavily infested leaves of various ages, a total of 20 dead and heavily curled up nematodes were found. Eight days later they were all dead. The recovered plant was kept under check and was observed to produce new leaves and after a long period of observation showed no traces whatsoever of a new infestation. The conclusion to be drawn from this is that repeated sprays with 0·05 % solution of "Systox" had a completely successful effect on the leaf nematode *Aphelenchoides fragariae.*

2. Effect of "Systox" on the chrysanthemum nematode *Aphelenchoides ritzema-bosi*

Chrysanthemums *(Chrysanthemum indicum)* heavily infested with nematodes were used as test material. At the bottom of the plant were a number of completely dried leaves and some of the leaves above these were completely turgid and showed large and small yellow to brown spots beginning at the base and extending between the main veins. The top young leaflets showed traces of early infestation; the flower buds were healthy.

a) Behaviour of the nematodes towards continuous toxic action (Fig. 4)

As in the case of *Aphelenchoides fragariae,* it was first of all intended to examine the behaviour of the chrysanthemum nematodes towards continuous toxic action (Fig. 4). Four test series each with 50 worms were arranged for each of the 0·05, 0·025, 0·017, 0·005 and 0·001 % concentrations of "Systox". In contrast to *Aphelenchoides fragariae,* the time necessary to obtain complete mortality for chrysanthemum nematodes amounted to 11—19 days, thus taking 7 days longer than the first species. When subjected to a 0·05 % solution of "Systox", 50 % of the worms were killed after 7 days, 75 % after 8 days, 94 % after 10 days and 100 % after 11 days. It took 11 und 12 days respectively to obtain a 94 % and a 100 % mortality with a 0·025 % toxic solution. Whereas 40 % of the nematodes in a 0·017 % solution of "Systox" died on the 9th day, the remainder had not succumbed to the poison until after 15 days. In a 0·005 % solution, 40 % died after 12 days, 70 % after 14 days and 100 % after 19 days. A similar result was obtained with a 0·001 % solution in which 75 % of the nematodes died after 15 days, 94 % after 17 days and 100 % after 20 days.

The check animals died after 57 days.

As in the case of *Aphelenchoides fragariae,* the striking factor of the continuous action of "Systox" on *Aphelenchoides ritzema-bosi* was the better effectiveness of "Systox" as compared with "E 605" conc. in that a 100 % kill was obtained 1—7 days earlier with 0·05—0·001 % concentrations (Fig. 4).

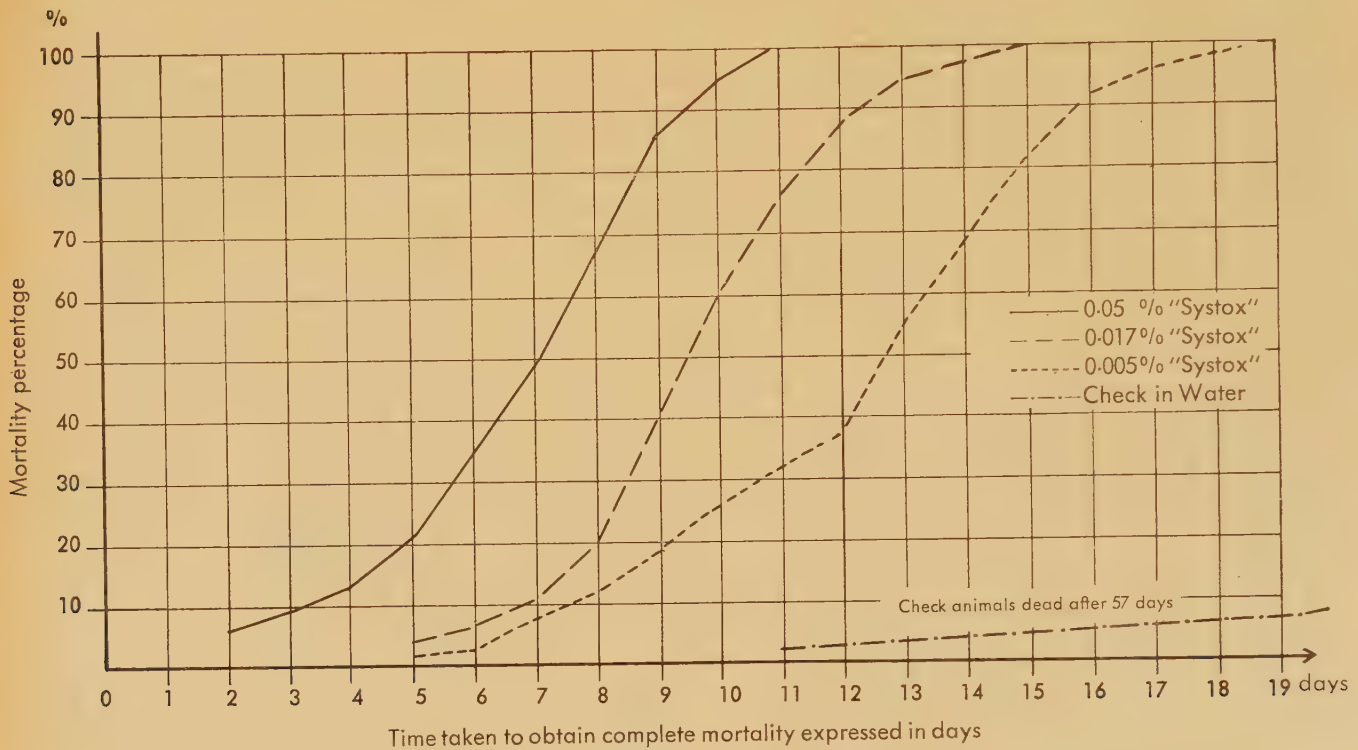


Fig. 4. Behaviour of *Aphelenchoides ritzema-bosi* towards continuous toxic action.

The mortality values of several "Systox" concentrations differ very little temporally, just as in the case of *Aphelenchoides fragariae.*

The greater resistance of *Aphelenchoides ritzema-bosi* as compared to *Aphelenchoides fragariae* was far more perceptible in the continuous test with "Systox" than with "E 605" conc. 100 % mortality was obtained with "E 605" conc. 2—3 days later in the case of *Aphelenchoides ritzema-bosi* than in the case of *Aphelenchoides fragariae,* whereas these periods obtained with various concentrations of "Systox" were 7—8 days longer for *Aphelenchoides ritzema-bosi* than for *Aphelenchoides fragariae.*

In contrast to the greater resistance in the continuous test, *Aphelenchoides ritzema-bosi* proved to be much more sensitive than *Aphelenchoides fragariae* when subjected to "Systox" for a short period. When the worms were transferred from water to the 0·05—0·005 % toxic concentrations of "Systox", the first paralytic symptoms became noticeable after 30 minutes and were exactly the same as those observed on *Aphelenchoides fragariae;* in a 0·05 % solution of "Systox" this paralysis was complete after 1 hour, in a 0·017 % solution after 1½ hours and in a 0·005 % solution after 3 hours. Even in a 0·0001 % solution, 30 % of the animals were curled up after 3½ hours and on the following day only 10 % of the animals were able to swim around freely (Table 2). In a 0·05 % solution of "E 605" conc. paralysis was first noticeable after 1½—2 hours, after 3½—4 hours in a 0·01 % solution, and after 7—8 hours in a 0·005 % solution.

The reaction period of *Aphelenchoides ritzema-bosi* is shorter than that of *Aphelenchoides fragariae* when subjected to "Systox", but the time taken to obtain complete mortality is very much longer in the continuous test. The cause of this difference in behaviour may be attributed to the fact that both species differ greatly in their ability to compensate for the poison. The higher the compensation ability, however, the greater are the demands made upon the organism. In the end, therefore, *Aphelenchoides fragariae,* which is more active and more capable of compensation but possessing fewer reserves, must succumb to the poison earlier than *Aphelenchoides ritzema-bosi* which compensates less actively but has a better reserve of substances. The slower the preparation acts, however, the more this varying high compensation ability appears to be covered and expresses itself finally in a greater or lesser resistance.

The fact that substances capable of resisting the poison are excreted by the organism even after the primary 100 % immobility makes itself noticeable in both nematode species after approximately 24 hours of toxic action by renewed feeble movements (Table 2) which are soon followed, however, by paralysis and death.

It took far longer to kill *Aphelenchoides ritzema-bosi* in the checks carried out at low temperatures than at room temperature. When subjected to a 0·05 % solution of "Systox" at 10—13° C, only 25 % were killed in the first 11 days, 75 % after 25 days and 100 % after 28 days; in a 0·017 % solution all the nematodes were still living on the 11th day, 28 % were dead after 22 days, 50 % after 25 days, and after a period of 28 days 60 % of the nematodes had succumbed to the preparation. It may thus be concluded that low temperatures are most unfavourable for the control of leaf nematodes with "Systox".

b) Behaviour of Aphelenchoides ritzema-bosi towards short-term action of "Systox" (Fig. 5)

The test arrangement was the same as that adopted for the tests carried out with *Aphelenchoides fragariae.* 50 nematodes were placed in each of the "Systox"

Table 2: **The course of movement inhibition** for *Aphelenchoides ritzema-bosi*. 100 nematodes were used for each concentration

Time	0·05% "Systox"	0·017% "Systox"	0·005% "Systox"	0·0001% "Systox"
12·00	All nematodes swimming freely	All nematodes swimming freely	All nematodes swimming freely	All nematodes swimming freely
12·30	60% curled up on the bottom of the test vessel	30% curled up on the bottom of the test vessel	All nematodes swimming freely	
12·45	80% curled up	50% curled up	10% curled up	
13·00	100% curled up with very little movement	70% curled up	30% curled up	
13·15	Half of the paralysed animals showing hardly any signs of movement	90% curled up	40% curled up but still signs of lively movements on the bottom of the vessel	
13·30		100% curled up but still signs of movement	80% considerably paralysed	
13·45	Only very weak movements	All nematodes curled up but still signs of movement		
14·00	Complete immobility			
14·45			100% curled up but signs of lively movements on the bottom of the test vessel	
15·15		Heavy paralysis		
15·30				30% curled up but still signs of lively movements
16·15		All worms immobile		
17·15			Still some signs of movement, all animals considerably curled up	
	After 24 hours again very weak movement	After 22 hours again very weak movements, nematodes not curled to such an extent as in 0·05%	After 21 hours renewed movements, somewhat more lively than in 0·017%	After 24 hours 90% curled up After 40 hours 100% curled up

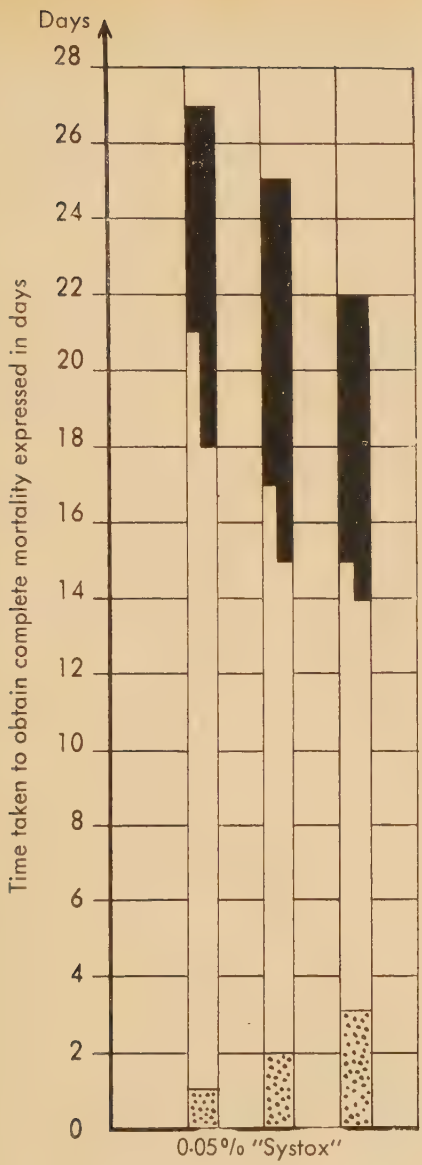


Fig. 5. Behaviour of *Aphelenchoides ritzema-bosi* towards a short-term action of a 0·05 % "Systox" solution.

concentrations of 0·05, 0·025, 0·017, 0·005 and 0·001 % and after being left in the toxic solution for 1, 2 and 3 days respectively were transferred to water. Just as in the tests carried out with *Aphelenchoides fragariae* the time necessary to obtain complete mortality in these tests was longer than in the fundamental tests and it took 22—27 days with a 0·05—0·017 % concentration, depending on the period of effectiveness, before all the nematodes had succumbed, whereas a further two days were required with the 0·005 and 0·001 % concentrations to obtain complete mortality.

These tests, like the continuous test, also illustrate the high resistance of the chrysanthemum nematode which exceeds the time necessary to obtain complete mortality by 2 days as compared with *Aphelenchoides fragariae.*

When compared with "E 605" conc., it appears that *Aphelenchoides ritzema-bosi* is better able to recuperate after being subjected to treatment with 0·05 to 0·017 % concentrations of "Systox".

Whereas *Aphelenchoides fragariae,* as a result of its higher compensation ability, was able to recuperate after 1—2 days in a 0·05—0·001 % concentration of "Systox" to the extent that it could again swim about quite freely for a short period of time, this was not the case wih *Aphelenchoides ritzema-bosi* after being subjected to 0·005 % "Systox" for only one day.

c) Behaviour of Aphelenchoides ritzema-bosi when subjected to repeated toxic action (Fig. 6)

The time taken to obtain complete mortality was also shortened by subjecting *Aphelenchoides ritzema-bosi* to repeated actions of "Systox".

The tests were carried out with the same concentrations as used for the short term action. After groups of 50 nematodes for each concentration had been subjected to treatment with "Systox" for 1, 2 and 3 days respectively, they were returned to water and on the 5th day they were again subjected to a dosage of poison of the corresponding concentrations for 24 hours. Subsequently all the nematodes were again transferred to water. As in the tests carried out with *Aphelenchoides fragariae,* success was realized very quickly with repeated toxic action also in this test series (Fig. 6). A 100 % mortality was obtained with 0·05—0·017 % concentrations not later than the 17th day of the test, and after 22 days with 0·005 and 0·001 % concentrations of "Systox". Even on the 7th day an average mortality value of 50 % was established for the 0·05—0·017 % concentrations for the first 3 day treatment, whereas in the case of the short-term tests carried out at the same time mortality at first amounted to 15 %. The difference in the primary effect was only noticeable in the final result in the case of those test animals subjected at first to the poison for a period of 3 days. Just as in the case of *Aphelenchoides fragariae,* the time necessary to obtain 100 % mortality within the concentration ranges of 0·05—0·017 % and 0·005 to 0·001 % was more or less the same.

The result of this test differs fundamentally from the result obtained with "E 605" conc. (Sachs 1952). In this case the worms succumbed to the poison in such a hesitating manner that, despite the second dosage of ester administered on the 8th day, only 30—40 % of the animals died and it was even necessary to apply a third dosage of ester. The result of this was that a 100 % mortality was obtained on the 14th day for the animals of the 0·05 % series, on the 16th day for those subjected to 0·033—0·025 % and on the 19th—21st day for the nematodes of the 0·017 % series.

Table 3:

	Aphelencho	
	"Systox"	
	0·05 0·017 %	0·005 %
Time required for the paralysis to set in, expressed in hours	0·75	1
Continuous action time required for a 100 % mortality expressed in days . . .	4 -8	12
Short-term action time required for a 100 % mortality expressed in days . . .	21—26	14—28
Repeated action time required for a 100 % mortality expressed in days . . .	8	12
Check time required for a 100 % mortality expressed in days . . .	43 —46	

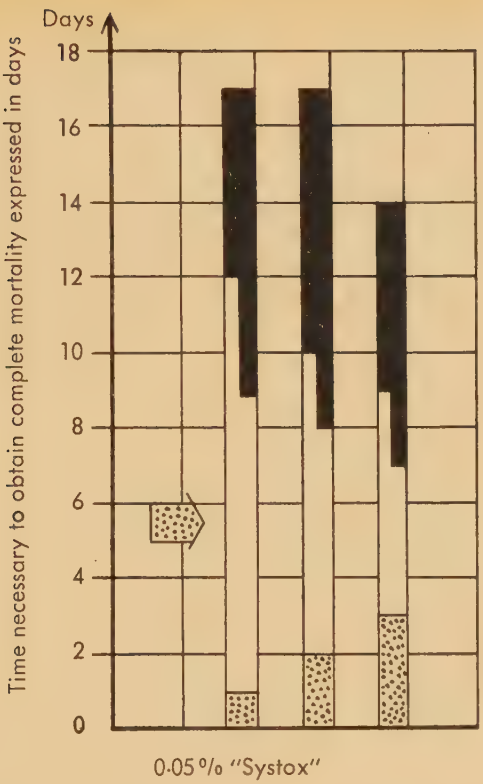


Fig. 6. Behaviour of *Aphelenchoides ritzema-bosi* towards repeated action of 0·05 % solution of "Systox".

ragariae		*Aphelenchoides ritzema-bosi*			
"E 605" forte		"Systox"		"E 605" forte	
0·05—0·017 %	0·005 %	0·05—0·017 %	0·005 %	0·05—0·017 %	0·005 %
1·5—3	4	0·5	0·75	2—4	7—8
7—14	23	11—15	19	10—16	26
8—18	24	22—27	24—29	14—23	44
8—10		14—17	22	14—21*)	
		57—60			

*) Primary action and 2 dosages of poison.

As in the case of *Aphelenchoides fragariae,* the fatal effect on the eggs of *Aphelenchoides ritzema-bosi* was only observed on the application of a 0·05 % solution of "Systox".

Table 3 shows in summary form the results of the effect of "Systox" as compared with the effect of "E 605" conc. on *Aphelenchoides fragariae* and *Aphelenchoides ritzema-bosi.*

d) Spray tests on chrysanthemums infested with Aphelenchoides ritzema-bosi

The nematode-infested chrysanthemums used for the tests were potted and kept indoors at a temperature of 18—20° C. They were exposed to plenty of fresh air and light. Four sprays of a 0·05 % "Systox" solution were applied at intervals of 3 days. 350 c.c. of toxic solution were sprayed on each plant. Particular importance was attached to wetting completely the upper and lower surfaces of each leaf. The nematode population of various leaves was checked on the 2nd, 5th, 8th and 11th day (Table 4).

Table 4: **Results of the spray tests carried out on chrysanthemums with a 0·05% solution of "Systox"**

	Old animals per sq. cm.			Young animals per sq. cm.		
	swimming freely	curled up	dead	swimming freely	curled up	dead
Prior to the sprays	220	30	—	50	—	—
Following the first spray	25	105	10	60% curled up		
Following the second spray	13	80	20	50% dead		
	18	55	6	12	40	12
Following the third spray	10	50	2	20 juveniles still living		
	15	30	4	10 paralysed larvae		
	12	10	2	5 paralysed larvae		
Following the fourth spray	—	5	2	—	—	—
	—	1	—	—	—	—

The nematode density per sq.cm. of heavily infested leaf blades amounted before spraying to 250 old animals and 50 young ones. Apart from a very small percentage of curled up animals, they swam about quite freely and energetically. The good infiltrating power of "Systox" became noticeable on the same leaf even after the first spray by the high percentage of curled animals and a recession of the population density to 140 animals per sq.cm. This density was further reduced to 113 animals per sq.cm. after the second spray, whereby 50 % of the young animals were dead. Another leaf not so heavily infested was colonized by a total of 79 old animals and 64 young ones. Following the three sprays, the leaf tissue was filled with many dead animals and in several leaf checks the

population density further receded to 62 per sq.cm., 49 per sq.cm. and 24 per sq.cm. respectively. The number of young animals had decreased considerably. Following the fourth spray five heavily curled animals and two dead ones were isolated from an old leaf and one paralysed worm from a heavily infested young leaf. All the other leaf checks which were investigated were found to be free of nematodes. The leaf tissue was heavily interspersed with dead worms.

The cured plants were kept under observation for a further period but there was no reoccurrence of the nematode infestation. The heavily infested leaves very soon became parched after the spraying tests had been completed and hung withered from the stem. At this stage, however, healthy shoots began to appear and even the yellow infestation spots of weakly infected leaves changed to brown, whereas the healthy leaves maintained their fresh green colour. After a short time the plants had recuperated to such an extent that apart from the bottom parched leaves they could hardly be distinguished from healthy plants. In contrast to these, the heavily infested plants which had not been treated with "Systox" continued to dry up and even the corollae became deformed as a result of the nematode infestation.

"Systox" sprays, repeated at short intervals, had therefore brought about the complete recuperation of the diseased chrysanthemums. It had already been assumed on the completion of the short-term model tests that a single treatment of plants infested by the resistant *Aphelenchoides ritzema-bosi* was not sufficient under normal conditions. Apart from the specific resistance of the parasite and the concentration applied, there are many exterior factors in practical application which play a part in influencing the effective toxic concentration. B o s s e (1952) observed in one particular case numerous living worms six days after he had watered nematode-infested chrysanthemums with a 0·1 % "Systox" solution in dull weather, whereas under different environmental conditions, namely hot dry weather and slightly withered plants, and using the same toxic concentration, there were no more living nematodes present on the plant on the day following the application and moreover the plants themselves continued to develop quite normally. The treatment of resistant parasites with "Systox" even under less favourable conditions as in B o s s e ' s last test can also be successful, as shown by the above-mentioned spraying tests, provided that the parasites absorb so much poison within the long period of time following repeated toxic action, that they are seriously injured.

3. The translocation of "Systox" in the plant

It was only possible to carry out relatively rough tests on the translocation of poison in the plant. The upper and lower surfaces as well as the leaf stem as far as the leaf base of young nematode-infested chrysanthemum leaves on various plants were thoroughly and repeatedly brushed with a 0·05 % solution of "Systox". Following three applications at short intervals, the check carried out on the treated leaves showed 65 heavily curled nematodes, 5 dead ones and 10 others swimming about freely. Almost all the larvae were dead. The conditions on the next leaf up the stem were similar. In this case there were 79 heavily curled up animals, 10 dead ones and 15 swimming about freely per sq.cm.; of the 22 young animals, 14 were curled up and 8 were swimming freely. The position on the next leaf which had 30 curled worms, 5 dead ones and 80 swimming freely was just the reverse; among the juveniles, three were curled, 2 were dead and 6 were swimming freely. As there is always a lower percentage of curled animals on untreated leaves, this result is very similar to that of an untreated leaf.

The outcome of these tests may lead to the supposition that "Systox" is chiefly conducted in an upward direction in the plant whereas it was hardly possible to establish a conduction to the lower plant parts with the aid of the nematodes.

4. Effect of "Systox" on other nematode species

For the purpose of drawing comparisons, several model tests were carried out with the widely propagated plant parasite, the stem eelworm *Ditylenchus dipsaci* and the free living species *Diplogaster maupasi* Potts 1910.

The stem eelworm *Ditylenchus dipsaci* from sick bulbs proved to be more resistant to the preparation "Systox" than the chrysanthemum nematode. The symptoms of paralysis proceeded in a manner similar to that observed in the case of the leaf nematode, namely the worms soon curled to a considerable extent, were shrivelled lengthwise and became immobile. The time necessary to obtain 100 % mortality in the case of a continuous application of a 0·05 % concentration amounted to 30 days; single laid eggs hatched out in this concentration.

Fully developed worms of the free-living nematode species *Diplogaster maupasi* bred on potato water agar revealed serious paralytic symptoms after being placed in a 0·05 % solution of "Systox". After 30 minutes, 3 of the 10 animals had already died, and 60 minutes later, a further 8 had succumbed. The survived, weakly trembling nematodes did not recuperate when transferred to fresh agar but died on the same day.

The effect was not so strong in a 0·017 % solution of "Systox". In this concentration all the worms had curled after 30 minutes and after 1 hour they were completely immobile. Three of the living animals were transferred to agar after repeated washing in water. They all lived and reproduced. The progeny was a quarter of that normally produced. The other worms which had been left in a 0·017 % solution of "Systox" died after 5 hours.

Free-living nematodes therefore appeared to be far more sensitive to "Systox" than those parasitizing on plants.

In another test carried out in a 0·017 % toxic solution, two young fully developed animals of the *Diplogaster maupasi* species were still living after being subjected to the treatment for 12 hours. One of the animals was left in the "Systox" solution. After another 2 days the worm was still living and had in fact multiplied by 12 lively larvae which within a further period of 6 days developed into puberal worms rich in eggs. The second generation emerged from the laid eggs on the 7th day. The check animals which had been placed in water at the same time had also laid eggs from which larvae emerged. These, however, did not develop into puberal animals but gradually starved.

The outcome of this test which contradicts all previous findings may be explained as follows:

Diplogaster maupasi is a saprobiont nematode species which can be easily cultivated on nutrient agar on which it feeds from the well-flourishing bacteria. Although the worms were washed a number of times before being transferred to the toxic solution, they probably had a number of putrefactive bacteria adhering to them and which also got into the 0·017 % "Systox" solution. Judging by the extent of reproduction and the formation of a whitish sediment, it seems that the bacteria found a good substrate in this solution. The molecule of the organic phosphorus compound "Systox", broken down into non-toxic fragments

by the ferments of the bacteria, was not injurious to the nematodes which, supplied with nutrition by the bacteria, reproduced over two generations.*

On the one hand, this may be regarded as a pointer to the way the nematode species *Diplogaster maupasi* obtains its nutrition, whereas, on the other hand, it would appear important always to use freshly prepared solutions in the practical application of "Systox" as a watering and spraying agent. The fact that the contamination of weak concentrations of "Systox", stored over long periods, by lower forms of living creatures, such as bacteria and fungi from the atmosphere, renders them ineffective as toxic solutions thus making them extremely welcome as nutrient substrates seems highly probable.

Particular importance was, therefore, attached to clean and, as far as possible, sterile work with freshly prepared solutions of "Systox" in all the model tests carried out on leaf nematodes.

A similar stimulation via the plants was obtained by Hahmann and Müller (1952) in the control tests which were carried out with "Systox" on strawberry tarsonemid mites. Whereas this preparation had a far better effect on the freshly sprouting plants in spring than did "E 605", the control of the mites with "Systox" in midsummer and late summer was not successful. A definite increase in the number of mites following the application of "Systox" on plants which had stopped growing was repeatedly observed. Presumably this is due to certain substances — like the ferments of the bacteria in the nematode tests — present in the degenerating plant itself, breaking down the "Systox" molecule into non-toxic constituents or incorporating the molecule in other new compounds which are beneficial to the parasites.*

5. Mode of action of "Systox" in the body of the nematode and in the plants

The toxic effect of "Systox" made itself manifest in the nematodes in a similar manner to that of "E 605" conc. Firstly the worms used in the model tests displayed great liveliness for short periods followed by trembling and cramped movements only to lapse into complete immobility. "Systox", therefore, appears also to have a contact effect on nematodes which come into direct contact with the preparation solution. It is quite certain that in all the model tests the preparation was also of significance for the nematodes as a hypertonic medium. It can hardly be ascertained from the prevailing toxic action, however, to what extent this osmotic factor influences the behaviour of the animals. Presumably "Systox" acts above all as a respiratory poison. The high volatility with water vapour at room temperature showed that the vapour pressure of "Systox" is greater than that of "E 605" conc. The higher the vapour pressure of the liquid, the greater is the kinetic energy of molecules leaving the liquid. In contrast to treatments with "E 605" conc., at the same test temperature, the shorter reaction period of the two nematode species after being placed in "Systox" is explained by the latter's very rapid infiltration into the body of the nematodes whereby it probably acts first and foremost in vapour form on the nematodes breathing through the skin. It was particularly in the continuous tests due to the considerable inhibition of breathing that this high vapour action, together with the effect as a nerve poison, made itself noticeable in contrast to "E 605" conc. by a considerable reduction of the life-span and the 100 % mortality period of the individual concentrations following each other at short

* Editor's note: the suppositions expressed here should again be subjected to a careful examination.

intervals. It is difficult to ascertain to what extent "Systox" acts as a contact, respiratory or stomach poison, because the various modes of action cannot be clearly defined. The nematodes living in the spongy parenchyma of the plant come into contact with the poison infiltrating through the stomata in the spray test and spread through the plant just as easily when it is in liquid form — because of the vapour-like excretion taking place in the course of time — as when it is in vapour form. The tests carried out with chrysanthemum nematodes at low temperatures may also be taken as a further proof of the strong respiratory action. At 10—13° C the vapour pressure of the preparation drops, and it then seems to penetrate slowly through the orifices of the nematodes chiefly in liquid form, because the semi-permeable plasma prevents the diffusion of dissolved substances through the skin. The result is that a far longer time is necessary to obtain 100 % mortality of the worms than when at room temperature. In the case of shortterm action, the ability of nematodes to recover when transferred to water is very great and in certain cases these nematodes recuperate to such an extent that they begin to swim again in a normal manner. Presumably "Systox", on the basis of its mode of action, does not cause damage as penetrating as that caused by "E 605" conc. following a single short-term application, or it breaks down more quickly or is excreted more rapidly in the body of the nematodes. Thus a longer life-span is made possible for those plant parasites in a relatively low organization stage and which still dispose of a certain quantity of reserve substances.

According to tests carried out with aphids (Unterstenhöfer 1951, Jancke 1951), the effect of these sucking plant parasites is based to a great extent on a respiratory action. The "Systox" absorbed by the plants appears to be slowly excreted again in vapour form by the green parts of the plant and in this manner has a direct and lasting effect on the sucking pests present on the stems and leaves. Furthermore, in the case of "Systox", the possibility of a partial inactivation by ferments in the plant itself may be entertained — as proved by Frohberger for "E 605" in the plant. This appears to be supported by the influence of the development stage of the plant on the success of the control. Zattler 1951, for example, when carrying out tests with red mites on hops during the period of blossom and umbel formation of the plant established a decrease in the otherwise very good continuous action from 4—5 weeks to 2 weeks. Hahmann and Müller were unsuccessful in their midsummer and late summer "Systox" treatment of strawberry tarsonemid mites on plants which had stopped growing, whereas the effect in spring was very good. In our own tests we were able to prove a breakdown of "Systox" and decomposition into harmless compounds by ferments of putrefactive bacteria.

The knowledge of the mode of action provides us with information on the correct application and the limits of effectiveness even of a systemic agent. It is here, however, that the conditions are particularly complicated, because the preparation transported in the sap stream of the plant acts in direct conjunction with the physiological process of the plant.

Up till now, "Systox" has proved to be very effective against sucking plant parasites. It was also possible to obtain complete success when correctly applying this preparation against such parasites as leaf nematodes which parasitize inside the plant and which are capable of resistance.

6. Hints on practical control

As the investigations disclose, "Systox" can be recommended as a good control agent for use in the field against leaf nematodes.

Good results were obtained by repeatedly applying "Systox" in spray tests carried out on fern plants infested with *Aphelenchoides fragariae* and on chrysanthemums heavily attacked by *Aphelenchoides ritzema-bosi*. Under normal conditions, a single spraying of the plants does not produce a satisfactory result. It would, therefore, be advisable, when working in the field, to apply 4—6 sprays of 0·05—0·1 % "Systox" solutions at short intervals of 3 to 4 days in order to exterminate the pests completely. The plants would then remain immune for a time against new infestations.

Apart from the concentration applied and the resistance characteristic of the pest species, the result of a spray is also dependent upon the vegetation stage and water content of the plant, the prevailing outdoor temperature and relative humidity. Therefore when applying "Systox" care should be taken that the preparation reaches the site of action as speedily as possible and that, wherever possible, the control is commenced as soon as the infection of the young plants begins, because the young leaves and shoots, in particular, quickly absorb the poison and translocate it to other parts of the plant. Under favourable outdoor conditions, aid can also be administered to the less turgid, old leaves which are already heavily infested by applying repeated sprays so that the diseased plants, with the exception of the withered, bottom leaves, again acquire a completely healthy appearance.

The control success achieved in the model test carried out on the stem eelworm *Ditylenchus dipsaci* still remains to be supplemented by practical tests.

7. Summary

1. Numerous model tests were carried out to test the effect of "Systox" solutions of varied concentrations on the leaf nematodes *Aphelenchoides fragariae* (from *Pteris*) and *Aphelenchoides ritzema-bosi* (from chrysanthemums). Generally speaking, the extermination of the worms parasitizing in plants was achieved more quickly with "Systox", due to its ability to effect rapid infiltration, than with "E 605" conc. in similar tests (Sachs 1952).

   The toxic action on both nematode species was made manifest by cramp-like, paralytic symptoms and soon brought about the death of the worms.

   In the case of continuous action of 0·05—0·0001 % solutions of "Systox" at room temperature, 4 to 14 days were taken to obtain 100 % mortality of *Aphelenchoides fragariae* (7 to 40 days for "E 605" conc.); for *Aphelenchoides ritzema-bosi*, 11—19 days were necessary when this species was subjected to 0·05—0·005 % solutions of "Systox" (10—26 days for "E 605" conc.).

   Because of its different mode of action, "Systox" requires a longer period than "E 605" conc. following a short-term application before completely controlling both nematode species: *Aphelenchoides fragariae* were all dead 21—26 days after the application of a 0·05—0·017 % solution of "Systox" (8—18 days for "E 605" conc.) and *Aphelenchoides ritzema-bosi* were all killed after 22—27 days (14—23 days for "E 605" conc.).

   Following repeated applications of "Systox", a 100 % mortality was very quickly obtained particularly in the case of *Aphelenchoides fragariae* which succumbed to the poison on the 8th—12th day (0·05 to 0·001 % "Systox"). *Aphelenchoides ritzema-bosi* had all died on the 14th—22nd day (0·05 to 0·001 % "Systox"). Despite three applications of "E 605" conc., 14—21 days had passed before *Aphelenchoides ritzema-bosi* were completely killed.

A 100 % mortality of *Aphelenchoides ritzema-bosi* subjected to a continuous application of 0·05 to 0·017 % "Systox" at 10—13° C was not obtained before the 28th day at the earliest.

It was only on applying a 0·05 % concentration of "Systox" continuously that a 100 % fatal effect on the eggs of both nematode species was attained.

2. The stem nematode, *Ditylenchus dipsaci*, and the free-living nematode species, *Diplogaster maupasi*, reacted to "Systox" in the same manner as the leaf nematodes in that they displayed similar paralytic symptoms.

   Despite subjection to the continuous action of a 0·05 % concentration of "Systox", 30 days had passed before *Ditylenchus dipsaci* were completely killed, whereas it only took 1—5 hours to kill completely *Diplogaster maupasi* with a 0·05—0·017 % solution of "Systox".

   The reproduction of *Diplogaster maupasi* over two generations in the model test carried out with a 0·017 % solution of "Systox" may be attributed to inactivation of the preparation by the ferments of bacteria which had been carried by the worms. "Systox" provided a suitable substrate for the bacteria which in turn were a source of nutrition for the worms.

3. The behaviour of the nematodes in the various tests has revealed that "Systox", besides functioning as a contact poison, apparently acts first and foremost as a respiratory poison through the skin of the worms.

4. Based on the spray tests carried out on nematode-diseased fern plants and chrysanthemums, it would be advisable to apply 4—6 sprays of 0·05—0·1 % solutions of "Systox" at short intervals of 3—4 days when controlling leaf nematodes in the field. This should guarantee a complete extermination of the pests and at the same time make the plants immune to infestation for 2—3 weeks.

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Tests to control the cherry maggot with phosphoric ester preparations

By Jos. Schmit, Luxemburg

The cherry maggot is to-day regarded as the greatest enemy of the cherry cultures in practically all cherry growing areas of Central Europe. It would not be an exaggeration to estimate the damage which this parasite has inflicted on local cherry plantations during the past few years at half the total value of the cherry production. Every year the cherry growers suffered palpable losses as a result of the activities of the cherry fruit fly, an insignificant insect which was unknown in our cherry growing areas until quite recently, without being in a position to protect themselves.

The control methods which in the past had been generally much praised, such as watering the area around the tree with tar oil wash, proved in practice to be difficult in their application and the results obtained never balanced the expenditure incurred for labour and materials etc. Just as in other countries the competent authorities in this country sought suitable agents and methods in order to pave the way for a rational control of this important pest. It was realized that unless this parasite could be controlled, our cherry cultures would have to be sacrificed in the future. When the "DDT" agents were made available after the last war, one was justified in reckoning with the possibility of an effective cherry fruit fly control particularly because these agents had proved to be very effective as contact poison against all fly species. Reports from Switzerland on the control of the cherry fruit fly with "Gesarol" carried out in joint actions indicated that results had been obtained which appear very promising for a general economical control of this pest. The local tests carried out in this country during the past few years with "DDT" preparations did not, however, produce the success expected. The reasons for this partial failure may be found in the following facts:

1.) Due to the lack of trained personnel and experienced local observers, it is very difficult to establish when the insect is on the wing and without this knowledge it is impossible to carry out an effective control of the fly with "DDT" agents.

2.) In view of the varied topographical and geological conditions prevailing in our main cherry growing areas, particularly in Trintingertal, locally

established flights are only of importance for a very limited area. As a result of the dispersal of the individual trees over the whole district and the occurrence of the cherry fruit fly at various intervals caused by the soil and surrounding conditions, it is more or less impossible to apply the necessary sprays at the right time in a joint action. To be on the safe side, one would have to carry out numerous joint sprays which, when considering the present day high prices charged for sprays and the low prices paid for cherries, could not be borne financially.

3.) Furthermore we have experienced how difficult it is to win over our cherry growers for a joint action in those cases where from the very beginning success is not expected. As individual sprayings with "DDT" agents were seldom successful, their application was again abandoned in our cherry growing districts. The same has been experienced in other countries.

This year the Board of Agriculture has carried out a series of new tests in the control of the cherry fruit fly.

Following the example set by the control of the olive fly in the South of France with bait sprays, and after it had been established that the insect was on the wing, the remotely situated cherry tree plantation on the road from Ötringen to Bous was treated with "DDT" and "BHC" washes respectively with an addition of molasses. Even though the buyers of the rather rich harvest in this country found a much lower percentage of maggots as compared with the previous years, the degree of success was nevertheless hard to determine.

A definite result, however, was obtained from the test sprayings carried out with phosphoric ester preparations in various cherry growing villages. These sprays were applied to late ripening cherry varieties which according to experience had been heavily infested in recent years. Whole trees as well as branch parts of single trees were treated at various intervals before the presumable harvest date. Contrary to the practice of applying preventive sprays with "DDT" preparations which aim at exterminating the cherry fruit fly and preventing the laying of eggs, an attempt was made in this case to eradicate the laid eggs or the young maggots which had already emerged before they were able to have caused any perceptible injuries.

Tests in Trintingen

Date of spray: June 12th; date of harvest: July 1st.

Spray agent applied: "E 605" German origin.

The check was carried out on the cherry harvest by means of the salt water method with the following results:

Treated varieties	Number of maggoty fruit on sprayed trees	on unsprayed trees
Ruya	6 % (half of the maggots were still very small)	52 %
Choque	0 %	13 %
Straussen	3 % (very small maggots)	58 %

All the trees were thoroughly treated with a high pressure motor sprayer although there is a possibility that several branch parts at the tops of the "Ruya"

variety which are old and very high trees were not completely wetted by the spray wash. The checked furits were taken in a haphazard manner from the small basket containing the harvested fruits.

The "Ruya" variety was partly treated with a 0·05 % concentration and partly with a 0·1 % concentration but no difference could be established in the effect.

Test in Dalheim

Date of spray: June 16th.

Spray agent applied: Parathion preparation, American origin.

Concentration: 0·05 %.

Treated varieties	Date of check	Number of maggoty fruit	
		Sprayed	Unsprayed
Ruya	June 23rd	4 %	38 %
Rote Knorpelkirsche	June 25th	6 %	52 %
Späte Schwarze	June 25th and July 1st respectively	4 % and 12 % respectively	48 % and 65 % respectively

Tests in Buchholzerhof

The spraying in Buchholzerhof was not carried out until the cherries had begun to ripen and until the maggots could already be detected on various fruits with the naked eye. Furthermore this test spray served the purpose of testing and comparing the two phosphoric ester preparations applied in Trintingen and Dalheim on the same varieties under the same conditions. The dosage applied was 0·07 %, in other words double the concentration usually recommended for both preparations in the other sprays. Date of spray: June 25th, date of check July 1st. The variety treated was a late ripening cherry variety, red "Knorpelkirsche". The spraying was carried out thoroughly by means of a knapsack sprayer on 15 year old trees bearing a very good crop.

The check carried out with the salt water method produced the following results:

On unsprayed trees and crown parts, 44, 47, 48 and 52 maggots respectively were counted per 100 fruit. Not a single living maggot was found on any of the treated fruits, although in individual cases a dead maggot was detected.

There was no difference in the action of the two preparations in these tests and the radical effect of both was the same.

Conclusion

These tests clearly indicate that it is possible to harvest cherries free from maggots by applying a single spray with phosphoric ester preparations. It is above all important that every fruit be wetted when carrying out the spray.

One of the great advantages of applying phosphoric ester preparations in the battle against the cherry maggot is that it is no longer necessary to comply with the difficult process of establishing when the insect is on the wing in order to fix a spray date but instead the determining factor for this is the stage of maturity of the fruit on all susceptible varieties. With respect to fixing the most favourable date for this spray, the results of the test spray show the following:

With sprays carried out 19 days before the harvest date (e. g. in Trintingen), very tiny maggots could be detected on single fruits after they were harvested; without doubt the eggs were not laid until a few days after the fruits had been treated, in other words not until the effect of the preparation had ceased. This is also confirmed by the treatment of the "Späte Schwarze" variety in Dalheim where more maggots were detected in the second check carried out on the 16th day following the treatment than in the first check on the 9th day following the spray. The spray was carried out much too early on these varieties.

On the other hand it was seen from the spray test at Buchholzerhof that the spray date fixed six days before the harvest was too late even though it had been possible to harvest cherries which contained no living maggots. In many of the fruits the maggots had grown to such an extent that the injuries they had inflicted and in fact the dead maggots themselves were still perceptible in the fruit. The most favourable date would be the average of these two intervals which would mean that the spray should be carried out approx. 12 days before the date of harvest.

The question now arises whether there are any doubts about consuming cherries already in the maturity stage which have been treated with such toxic preparations. We know that all phosphoric ester preparations are highly concentrated poisons which even when taken in very small doses in an undissolved concentration can have the most serious consequences for humans and animals. Even when applied in the usual spray wash concentrations, be these as low as they may, these preparations have a marked toxic effect, otherwise they would not be able to exterminate insects which had already penetrated deep into the fruit. However, it is also a fact that the phosphoric esters evaporate quickly and, a point which must really be regarded as a disadvantage in the control of parasites, that they lose their toxic effect within a few days without leaving any traces behind which would cause injury. The author is in a position to prove this fact in that he himself ate more than 100 cherries which had been sprayed with a 0·1 % concentration barely 5 days beforehand without noticing any change in taste or experiencing any unpleasant after-effects. Even the farm hand at Buchholzerhof ate a considerable quantity of cherries from sprayed trees despite the warning of his employer and he said afterwards that he had enjoyed them very much and had not suffered any pains in the stomach. Even cherries examined in the laboratory of the Agricultural Experimental Station in Ettelbrück 4 days after they had been sprayed with phosphoric ester showed no signs of any toxic residual substances.

The costs incurred for a treatment of cherry trees with phosphoric ester preparations are not so high as those for any other tree spray. The direct costs for the treatment of an average size cherry tree without expenditure for labour and the use of equipment is approx. Fr. 13 which for the cherry grower amounts to the value of 2 kg of cherries. When it is considered, however, that the grower is able to save at least 100 kg of fruit per tree by the application of a single spray before the quality of the fruit is diminished by the cherry maggot, it may be said that this is sufficient proof of the economy of maggot control. And should our cherry growers realize the necessity of a single treatment of every tree of the maggot-endangered varieties in their district which after all is not an unusual undertaking, it will be possible by means of such a joint action to free whole areas of maggots for years to come without having to carry out a special treatment of the trees against this pest in the following years. The prerequisite for the complete success of such an action on a broad basis, however, is that each tree must be thoroughly sprayed and furthermore many large old trees

whose tops can only be wetted with difficulty even by the most powerful spray jets must be completely removed or should they still be in a healthy condition they would have to be lopped considerably.

At all events our cherry growers at long last have a suitable agent at their disposal in order to defend themselves against the greatest enemy of their cultures.

The Tortrix Moths of Our Fruit Trees

By Dr. Ir. A. Soenen,
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1. Introduction

During the past few years the attention of fruit growers has been drawn more and more to damages inflicted upon their orchards by the tortrix moths. This applies particularly to apple and pear trees. We have a relatively large number of tortrix moths which infest our deciduous trees; every year about half a dozen of these microlepidoptera cause more or less considerable damage. Three species appear to have been parasitizing on our fruit trees for a long time now, during the course of which they have attained a certain significance. They are:

Cacoecia lecheana L.,

Tmetocera ocellana Fab.,

Argyroploce variegana Hb.

Since 1944 a species has developed in the Western European countries which alone causes far greater damage than that of all the other species put together. We established some time ago that this species is *Capua reticulana* Hb. It is practically a new species for our fauna and occurred chiefly in Belgium in 1945 and 1946, developing into one of the major pests of our fruit cultures. Thanks to an effective control carried out in recent years, *Capua reticulana* nowadays plays a lesser part in Belgium and no longer presents such a serious problem in that country. On the other hand, it developed to a far-reaching extent in the north of France and the south of Holland in 1948. At present it has become a serious problem to fruit growers in Kent, England.

2. Description of *Capua reticulana*

The fully grown insect is a small tortrix moth which, in its proportions, resembles the codling moth. The head and thorax are beige and the posterior wings vary from pale brown to light beige. The anterior wings are diagonally lined with brown stripes. The female is generally larger and darker in colour than the male.

3. Biological life-cycle

The insect overwinters as a larva; it is yellowish and hibernates in a small white protective integument which it spins in October. This integument which provides an excellent protection against the cold and weather influences is

located at the bases of leaves and flower buds. The winter quarters are often set up between a dead leaf and a branch, although in many cases the larva may also be found under the cover of the bark and sometimes even in the cords which secure the young trees to the supporting stakes. The winter quarters generally consist of 2—3 layers of silk threads; the thickest part is a web in which the larva embeds itself.

The larva leaves its winter quarters during April and immediately begins to feed on buds; it pupates in the foliage. The fully grown insect of the first generation emerges at the end of May. The eggs are laid on the upper surface of leaves or even on fruit in disc-shaped batches of 30 to 110. As soon as the eggs have hatched, the young larvae move to the leaf bases and mostly spend the first part of their larval life on the midribs of the leaves where they seek protection under a thin white web. Later when the caterpillars have reached the maturity stage, they feed on leaves and spin silk threads which draw together the young leaves at the extreme tips of the young shoots. They can also live in a part of a curled-up leaf. Very often the larvae are detected in the depression where the stalk touches the fruit. The fully grown caterpillar is approx. 2 cm long and has an olive-green colour. The larva is particularly nimble. As we have already mentioned above, the pupation takes place in a rolled-up leaf.

In Belgium the insect produces 2·5 generations annually, which means that in certain cases there is a third generation. It should be mentioned that the larvae appearing in April do not originate from the first generation but from a second or even a third generation of the previous year. It is therefore possible to encounter four different caterpillars during the course of the year. Over a period of 8 months from October until May one only encounters larvae of the second generation, in June fully grown insects and eggs, and in the second half of that month caterpillars. Fully grown insects and caterpillars are prevalent in July whereas the chrysalis stage of the first generation is to be found in the second half of August. In addition to these the following may also be encountered in August:

chrysalises of the first generation,

larvae of the first generation during the first half of the month,

larvae of the second generation towards the end of the month,

fully grown insects of the second generation during the whole of the month, and

eggs of the second generation during the second half of the month.

The biological life-cycle of this characteristic species is therefore very complicated due to the fact that the individual generations overlap each other.

4. Nature of injuries inflicted

The damages caused by this tortrix moth are of a varying nature:

a) Damages to the buds: At the beginning of the year spots are often observed, which reveal the chewing activities of the moth; this is often responsible for the destruction of the complete flower clusters.

b) Damage to the leaves: These damages are exceptionally great and chiefly caused in July and August by the caterpillars of the first generation. In cases of heavy infestation there is the possibility of all leaves at the tips

of the shoots being destroyed. These damages generally start on the lower surface of the leaves giving the impression that they have been cut to pieces, and are caused by newly hatched larvae. Later the leaf parenchyma is completely destroyed in certain cases, with the result that the caterpillars only leave behind a very thin reticulation. Furthermore, the caterpillars fold together a leaf strip over the remainder, the larva eats its way through the parenchyma in a more or less straight line which as a rule begins at the leaf stalk, the leaf curls up and the larva continues to live between the two intact parts of the parenchyma.

c) Damage to the shoots: When they occur in large numbers, the caterpillars of the first and even the second generation attack the young shoots. The extreme tips of the young leaves are bound together with silk threads and the shoot gradually dies off.

d) Damage to the fruits: The most serious damage is inflicted on the fruits. The larvae of the second generation prefer to hide themselves in the vicinity of the stalk. Mostly they are found at the point where two fruits touch each other and it is here that they slightly chew away the peel. In addition, fungus spores penetrate through the chewed spots into the interior with the result that fruits attacked in this manner by tortrix moths are subject to decay. These damages may become very serious when the weather in September is warm and dry. One larva is capable of destroying several kilos of fruit in a single day; therefore it is essential to sort the fruit during the harvest and to eradicate any larvae found there. These injuries continue to develop on the fruit trees and may assume catastrophical proportions should the fruit be stored in refrigerators and then placed in shop windows.

5. Control Agents

A. Treatment in winter

We carried out numerous tests for the first time in 1946 by winter-spraying *Capua reticulana*. Since that time we have tested various products, particularly organic dyestuffs such as sodium dinitrocresylate, tar oil and DNC mineral oil combinations. It should be mentioned that tar oil in solutions is ineffective when applied against *Capua reticulana* on fruit trees whereas the other two agents are effective to a certain extent. Numerous tests carried out regularly during the past few years have enabled us to draw the following conclusions:

a) The organic dyestuffs, pure or mixed with mineral oils, produce varying results on the overwintering caterpillars.

b) It is advisable, as far as this is possible, to carry out the treatment in late spring.

c) It is recommended to apply these agents in wet weather. The water used for this purpose should have a low pH-value.

d) There was not a single case where a 100 % result was obtained. It is always possible to find larvae which are protected in such a manner that they cannot be eradicated by any agent.

Field control of *Capua reticulana* is preferably carried out in winter. This winter treatment, however, is not sufficient on its own to eliminate the pest infestation completely.

Fig. 1. Young shoot of an apple tree (Abart Jonathan) infested by a larva of *Capua reticulana Hb.* (Leaf roller)

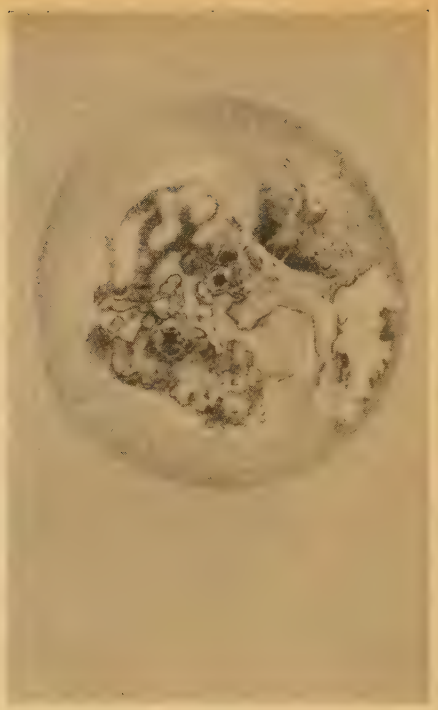

Fig. 2. Sir James Grieve: Damages caused by *Capua reticulana Hb.* (Leaf roller)

B. Spring and summer treatments

Fortunately it is possible to carry out an effective control of the first and second generations of *Capua reticulana*. We would emphasize the necessity to concentrate the control on the first generation in order to exterminate the pests as speedily as possible. This can be accomplished by applying either thiophosphate or "DDT".

a) These two products are exceptionally effective against moths. In practice, therefore, a treatment would be completely effective if the period when the moth is on the wing were limited; as this, however, is not the case and the various stages of development overlap each other, this control in itself is not sufficient.

b) The phosphor-containing esters ("E 605") have an ovicidal effect.

c) Phosphor-containing esters should be applied against the young larvae. In certain tests we have obtained 100 % results on young larvae because these agents penetrate deeply into the leaves. Even those larvae protected by a fine web are exterminated.

d) "E 605" or "DDT" or more preferably a mixture of both should be used against the fully grown larvae.

6. Summary

Seeing that *Capua reticulana* is regarded as one of the chief parasites occurring on our pomaceous fruit trees, it is essential that the fruit growers do their utmost to destroy the pests propagating in their fruit cultures.

For this purpose the fruit grower has several pesticides at his disposal:

A. Organic dyestuffs for treatment in winter.

B. Treatment carried out simultaneously with phosphor-containing esters against imago, eggs and larvae.

C. Either phosphor-containing esters or "DDT", or a mixture of both, against the fully grown caterpillars.

Field Tests with the Systemic Insecticide "Systox" against the Bean Aphid *(Doralis fabae Scop.)* on Horse Beans *(Vicia faba L.)*

By Dr. Unterstenhöfer

Introduction

In 1951 large-scale field tests were carried out with the preparation "Systox" on *Vicia faba L.* subsequent to extensive tests in the laboratory and in the greenhouse. In these tests it was established that on applying a 0·05 % concentration at the rate of 600 litres per hectare (300 g of preparation per hectare), a penetrating effect could be obtained which lasted for approximately 10 days. Furthermore, it was observed that the development of the plants was promoted to an unexpectedly large degree and that the yields increased. These were effects which, according to our experiences with other aphicides, although not systemic and thus not effective for the same length of time, had not usually occurred to this extent. As the tests were arranged for the purpose of obtaining a general confirmation of our experiences gained from the laboratory and greenhouse tests, as well as in outdoor tests against other pests on various cultures, but not in the strict sense of precise tests, the observations could not be regarded as being completely reliable but were more or less intended to serve as a basis for precise tests to be made at a later date, since it had to be taken into consideration that these determinations would be purely casual and without any reliability. The tests, however, again confirmed that the horse bean is extremely suitable as a plant object for the general study and assessment of the value of aphicides because this plant is attacked by the bean aphid practically every year to such a degree that there is every prospect of being able to assess the real value of the control agent with certainty. This means that interruptions in the test activities caused by an inadequate infestation density are reduced. In the meantime, the investigations of Davidson (3), Ibbotson and Kennedy (4) and Kennedy and Booth (5) on the biology and epidemiology of *Aphis fabae* have been supplemented by the valuable papers of Müller and Unger (7, 8) in such a manner that a suitable test plot and the interpretation of test results in the interest of a satisfactory assessment of the value of aphicides may be regarded as being quite possible. With that, the value of the test object under discussion has increased as a methodical aid in the testing of pesticides. The

tests carried out in 1952 were intended to illustrate more clearly the effects of "Systox" after its application against the bean aphid on horse beans. For this purpose it was intended to create varying degrees of damages caused by the aphid corresponding to several intensive preparation effects on the plant by using several sprays applied frequently and with different concentrations.

Plotting of Test

When plotting the test, importance was attached to creating conditions which would permit a precise test to be carried out under extremely hard conditions. That had to be achieved by repeating the tests several times and by using plots as small as possible but which could just the same be regarded as admissible for the purpose. The following spray measures were suggested for the vegetation period:

B	$1 \times 0{\cdot}05$ %	D	$2 \times 0{\cdot}05$ %	F	$3 \times 0{\cdot}05$ %
C	$1 \times 0{\cdot}1$ %	E	$2 \times 0{\cdot}1$ %	G	$3 \times 0{\cdot}1$ %

600 litres of spray wash were applied per hectare by means of a Holder vine sprayer. In a separate test row, seeds were treated with a special powder preparation of "Systox" with which the beans had been treated at a rate of 2 : 1000 (A). This row was not sprayed during the vegetation period. The treatment was based on the idea of providing the seeds with a depot of active ingredient from which the plants should absorb the preparation for a certain period of time. Corresponding preliminary tests had shown that this was quite possible.

Each treatment was repeated 4 times. The size of the plots was 20 sq. m. (4×5 m). The intervals at which the single repetitions were carried out coincided with those laid down in the test plan.

The bean variety which we used was the white-eyed "Zwyndrechte". The beans were set on April 15th, 1952, with 2 beans per planting hole at intervals of 50×40 cm.

The field which had borne rye as its previous crop was fertilized before the winter with stable manure and again in early spring with 60 kg of P_2O_5 per hectare and 100 kg of K_2O per hectare in the form of Thomas meal or a 40 % potash salt.

Observations during the test

The special weather conditions during 1952 were responsible for an unusually heavy infestation of bean aphids. At the beginning of May *Doralis fabae* started to colonize the bean plant and by the end of the same month approx. 80 % of the plants in the untreated plots had been populated, whereby it is worth mentioning that the infestation was distributed uniformly corresponding to the size and the purposely chosen form of the test field. As a result of more and more aphids flying on to the field, an activity followed qualitatively with the "Möricke" bait trap, the extent of the infestation increased progressively. By the middle of June, 98 % of the check plants were covered with what were generally very large colonies. About the 28th of June the effects of the calamity suddenly came to an end within a very few days, probably due to the high temperatures prevailing at the time. Even though large numbers of predatory insects, predominantly *Coccinellidae*, were present very early on, it could not be said that they were chiefly responsible for bringing the calamity to an end.

The appearance of the aphids in very large numbers led to marked catastrophical results in the untreated plots. The infested plants wilted and their

Test plan

G_4	O_4	$+$ G_3	D_3	E_2	G_1 $-$	A_1 $-$	O_1
$+$ E_4	A_4	E_3	B_3	C_2	F_2 $-$	O_2 $-$	B_1 $-$
C_4	D_4	F_3	$+$ O_3	$+$ A_2	G_2	C_1 $-$	$+$ D_1
B_4	$+$ F_4	$+$ C_3	A_3	D_2 $-$	$+$ B_2	E_1 $-$	F_1

Doralis fabae on Horse Beans. Foreground: untreated.
Background: sprayed with "Systox"

blossom which had been more or less completely destroyed was sparse. The sad appearance of the plants was intensified by the thick coat of honey-dew on which sooty moulds had colonized. In certain cases, the leaves revealed marked necrosis apparently a result of the coating of honey-dew. Without doubt the production capacity was additionally weakened by the aphid excretions.

Apart from the bean aphid, *Sitona lineata* and *Apion pisi* appeared during the course of the vegetation period without, however, causing any mentionable damage to the yield. On the other hand, practically all the plants developed mosaic diseases in the course of time.

Carrying out of tests and their evaluation

The sprays and evaluations were carried out on the following dates:

1st spray on May 18th, 1952 — 1st evaluation on May 30th, 1952
2nd spray on June 4th, 1952 — 2nd evaluation on June 6th, 1952
3rd spray on June 17th, 1952 — 3rd evaluation on June 19th, 1952

The evaluations, subsequent to each spray, were carried out qualitatively to establish the location of the infestation and not its density. In fact it was practi-

cally impossible to determine the density of the infestation because the colonies were so thickly populated that a numerical valuation could simply not be carried out. We assessed the plant as being infested when unwinged aphids were present on at least one shoot irrespective of the number and the age of the aphids. As a result of this, the evaluations also included those cases where winged aphids with few, although in most instances recently deposited, young aphids were found, without taking into consideration whether these were able to adhere to the treated plant. Accordingly, the outward appearance of a dense infestation does not indicate the actual degree and thus the importance of the infestation. Shoots which were colonized only with winged aphids were on the other hand not regarded as being infested.

In accordance with the test problem, the total weight of all plants harvested (herbaceous parts, roots and pods) and the weight of the pods were estimated separately at the harvest reaped on July 23rd, 1952.

Results

The values obtained from the assessments of the infestation and the harvest are compiled in the following tables. Columns 2 to 7 give the average values together with the corresponding standard deviation of means as calculated from the four repetitions. Underneath these columns are the P-values for the interesting comparisons computed according to the t-test.

The table primarily reveals that when the number of sprays applied increases and the concentrations are stronger, the density of infestation recedes during the vegetation period and the yields are larger. It was merely the application of a 0·1 % concentration repeated three times that produced lower yields than a 0·05 % concentration applied three times. This difference, however, cannot be vouched for, as the P values show (F : G — P = 0·61 — 0·8 — 0·4).

Even the single seed treatment stands out significantly from the check (0) at the time of the first infestation evaluation and in the harvest, but it far from reaches the values of the sprays. Nevertheless, it is a clear confirmation of tests previously carried out with "Systox" seed dressing. When the density of infestation in the dressed row during the period of vegetation is compared with the harvest yields, it is seen that the plants have developed a certain resistance apparently due to the influence of the treament, which leads to higher yields.

The single spray with 0·05 % "Systox" destroyed the population present on the plants immediately following the treatment. However, during the course of the vegetation period the plants were re-colonized as a result of aphids flying onto the field and others migrating from the check stocks, but this, however, did not lead to a total infestation. The harvest yields, and in particular the pods, showed that the plants were considerably unburdened by the treatment and were able to produce a yield twenty times that of the untreated check plants or practically five times that of the dressed plants. These differences are secured (A : B — P = 0·002). It is worth mentioning that the quantity of herbaceous parts and roots is not so great as that of the dressed plants, although the difference may not be regarded as secured. (P = 0·36).

In principle the same applies to the 0·1 % concentration applied once, whereby the infestation is somewhat less than that of the 0·05 % concentration and the harvest is bigger. The infestation and yield differences are, however, not guaranteed (B : C — P = 0·13 — 0·8 — 0·53 — 0·24 — 0·11 — 0·5). As far as the yield is concerned, however, the large average error should be observed with which the C row is affected.

Treatment	1 Average Stock per plot (planting holes)	2 Average Infestation after 1st spray	3 Average Infestation after 2nd spray	4 Average Infestation after 3rd spray	5 Total plant sto in 100 kg/he
C=Check	96	76±2·75 (=79·1%)	88±4·6 (=92%)	94±7·84 (=98%)	75·35±7
A=dressed	97	54·5±5·55 (=56·2%)	83±4·45 (85·5%)	86±6·22 (=88·6%)	113·25±6
B=1×0·05	90	10·5±1·04 (=11·6%)	49±13·68 (=54·5%)	35±12·5 (=38·9)	150·15±1
C=1×0·1	97	6·5±2·02 (=6·7%)	45±5·0 (=45·3%)	22±14·6 (=22%)	195·00±3
D=2×0·05	94	6·0±1·47 (=7·2%)	15·25±5·55 (=16·21%)	4·25±1·65 (=4·5%)	223·05±1
E=2×0·1	93	3·75±1·75 (=4·4%)	12·5±5·36 (=13·45%	4·75±2·75 (=5·1%)	229·55±1
F=3×0·05	97	8·25±2·78 (=8·5%)	1,5±1·5 (=1·55%)	2·25±2.25 (=2·31%	260·85±2
G=3×0·1	91	4±2·04 (=4·4%)	3·75±2·39 (=4·12%)	2·5±2·5 (=2·75%)	247·10±4

To Col. 2	To Col. 3	To Col. 4
O : A—P = 0·012	O : A—P = 0·48	O : A—P = 0·45
O : A—P = 0·0002	O : B—P = 0·035	O : B—P = 0·007
B : C—P = 0·13	B : C—P = 0·8	B : C—P = 0·53
A : B—P = 0·0002	A : B—P = 0·05	A : B—P = 0·011
	B : D—P = 0,06	B : D—P = 0·049
	C : E—P = 0·004	C : E—P = 0·28
	C : D—P = 0·002	C : D—P = 0·21
	D : E—P = 0·74	D : F—P = 0·5
		E : G—P = 0·52
		E : F—P = 0·5

6 Herbaceous parts and Roots n 100 kg/hectare	7 Pods and Beans in 100 kg/hectare	8 Relation of Herbaceous parts and Roots to Pods	9 Pods in % of total plant stock	10 Yield Increase (Pods) 0 : 1	11 Yield Increase (Herbaceous parts and Roots) 0 : 1
72·50 ± 8·25	2·87 ± 1·32	100 : 4	3·8	1·0	1
100·00 ± 4·05	13·25 ± 1·18	100 : 13	11·8	4·7	1·38
93·75 ± 7.75	56·40 ± 9·10	100 : 60	37·5	20·5	1·29
125·00 ± 16·05	70·00 ± 16·0	100 : 56	36	25	1·72
143·10 ± 7·70	79·95 ± 3·60	100 : 56	35·8	28·6	1·97
133·75 ± 5·15	95·80 ± 7·60	100 : 71	41·7	34·3	1·85
146·25 ± 18·95	114·30 ± 9·17	100 : 78	43·5	40·7	2·07
141·25 ± 0·75	105·95 ± 3·66	100 : 75	43·0	37·5	1·95

To Col. 5	To Col. 6	To Col. 7
O : A—P = 0·012	O : A—P = 0·03	O : A—P = 0·016
D : F—P = 0·2	D : F—P = 0·88	D : F—P = 0·012
B : C—P = 0·24	B : C—P = 0·11	B : C—P = 0·5
A : B —P = 0·01	A : B—P = 0·36	A : B—P = 0·002
B : D—P = 0·012	B : D—P = 0·004	B : D—P = 0·04
C : E—P = 0·35	C : E—P = 0·62	C : E—P = 0·21
C : D—P = 0·56	C : D—P = 0·38	C : D—P = 0·55
D : E—P = 0·73	D : E—P = 0·35	D : E—P = 0·12
F : G—P = 0·61	F : G—P = 0·8	F : G—P = 0·4
B : F—P = 0·011	B : F—P = 0·025	B : F—P = 0·007
C : G—P = 0·14	C : G—P = 0·38	C : D—P = 0·06
E : G—P = 0·25	E : G—P = 0·19	E : G—P = 0·28
E : F—P = 0·32	E : F—P = 0·52	E : F—P = 0·18

Two sprays with 0·05 % "Systox" resulted in a further reduction of the infestation during the vegetation period and an increase in the harvest. When the single 0·05 % spray is compared with two treatments with a 0·05 % concentration, significant differences are arrived at with respect to the infestation and the harvest (B : D — P = 0·06 — 0·049 — 0·012 — 0·004 — 0·04). With the exception of the infestation following the second spray, the difference between a single 0·05 % spray and two sprays of a 0·05 % concentration is, however, not statistically secured (C : D — P = 0·002 — 0·21 — 0·56 — 0·38 — 0·55), although once again the high standard deviation of means of C should be taken into consideration. Even though two applications of a 0·1 % concentration result in a decrease of the infestation and an increase in yield as compared with two applications of a 0·05 % concentration, these differences should not be taken as secured. (D : E — P = 0·74 — 0·73 — 0·35 — 0·12). It is above all noteworthy that, with the exception of the difference following the second spray, the difference in infestation and yield between the single application of 0·1 % and two applications of 0·1 % is not to be regarded as significant (C : E — P = 0·004 — 0·28 — 0·75 — 0·62 — 0·21) as opposed to the difference between the single spray and two sprays of a 0·05 % concentration.

When a concentration of 0·05 % is applied three times, another increase in yield together with a drop in the degree of infestation may be registered. It is only in the pod yield that a definite difference may be found between the second and third sprays of the 0·05 % concentration whereas there is no difference with regard to the infestation (D : F — P = 0·5 — 0·2 — 0·88 — 0·012). Although only very slight, a retrogression in the effect and in the harvest may be established for three sprays of a 0·1 % concentration but this is not significant.

It is worth mentioning that no subsidiary effects on bees were observed. No dead bees were found in the stock and in fact the death rate did not increase in our beehive during the period in question. Furthermore no harm was done to coccinellidae.

Discussion of Results

The enormous increase in yield in 1952 resulting from the influence of "Systox" applications may be regarded as a standard just as little as the aphid attacks of this year. Without doubt these are extreme cases but it is just these that are particularly appropriate in the study of the fundamentals.

The question as to the effects of increasing quantities of "Systox" is answered, as was shown, in that these increases result in decreasing degrees of infestation during the vegetation period and increasing yields both according to the total plant stock as well as according to the pods. Even though the single yield increases in the single stages may not always be regarded as authoritative from a statistical point of view, the uniform tendency is noteworthy and probably gives an indication of the course to be adopted. It is here that the problem of the above mentioned test may be found which it is now our intention to discuss. For this purpose the single values have been further calculated and the results are reproduced in columns 8—11. In column 8 the relation of herbaceous part and roots to pods is given. This calculation based on the values in columns 5—7 has proved to be suitable. It was shown here, however, that the increasing tendency is least expressed in column 6 (herbaceous parts and roots) and these values exhibit fundamental differences compared with the values in columns 5 and 7. It is seen from column 8 that the margin between herbaceous parts and roots on the one hand and pods on the other hand becomes continually narrower. Column 9 shows further that when the quantities of spray applied

are increased, there is alway a greater proportion of pods in the total plant stock and they increase from almost 4 % on the check plants to 40 %. Columns 10 and 11 reveal that the pod yields do not increase as uniformly as the herbaceous parts and roots due to the influence of the treatments; in the former by fortyfold and in the latter by twofold. The generative ability of the bean therefore derives a considerably greater profit from the application of "Systox" than the vegetative development. That can be attributed either to a particular sensitivity of the blossom and young pods to the sucking activity of the bean aphid in a severe infestation which results in a shortage of albumen in the plant thus promoting, as is known, the formation of winged aphids, or else to the effect of the preparation in a somewhat "stimulative" form. Even this question cannot be answered. It is here that a sensitive gap is revealed in our knowledge about the effect of the sucking activity and the honey-dew coating of *Doralis fabae*. Irrespective of questions concerning profits, a more noteworthy effect of the application of "Systox" on the ability of *Vicia faba* to produce high yields is indicated here and in such a manner that with an increase of the harvest there is a better interest on all other expenditure incurred by work and capital. Whether this fact is the result of a specific property of "Systox" or is a general consequence of the aphid control on *Vicia faba* cannot be answered because, according to our knowledge, no reference has been made to this. Should it turn out to be a specific property of "Systox", then a way is opened to increase the productivity of *Vicia faba*. An investigation will have to be made to determine whether, and to what extent, this also applies to the other cultures. References on this are available for hops and beets.

The special conditions prevailing in 1952 make it all the more difficult to decide which dosage and what number of sprays can be regarded as the maximum. As far as the seed treatment is concerned, it is quite conceivable that this measure suffices in many a year. The values available show a good effect. Therefore when carrying out future tests, serious consideration should be given to a prophylactic seed treatment and spray measures should only be applied if required.

Among the spray concentrations applied, it is the 0·05 % concentration that does not achieve the maximum effect. However, on comparing its effect with that of the 0·1 % concentration, it does appear to approach the maximum because the better effect of the 0·1 % concentration is paid for dearly by overproportionate application. An observation already made is confirmed that frequent sprays of small, although effective dosages are more suited to the purpose than few sprays of high dosages.

Summary

In precise field tests a check was made on the effect of the seed treatment and the increased dosages of "Systox" in the form of various sprays applied frequently with varied concentrations against *Doralis fabae* on *Vicia faba*. When evaluating the tests, consideration was given to the special conditions of 1952 with regard to the drop in infestation and the yield increase, with the following result:

1. The seed treatment, as compared with the untreated check plot, produced a decrease in infestation and an increase in yield secured statistically.
2. An increased number of "Systox" sprays produces a gradually improving effect on the aphids and a yield increase.
3. In particular, consideration is given to the yield increase whereby it is seen that the pod yield increases absolutely and relatively.

4. Particular significance is attached to the relative yield increase because this provides references for an increase in the productivity of the soil, for the economical importance of aphids, and for the effect of the preparation "Systox" on the aphids and the plants.

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Economy of the Cockchafer Control

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Field workers in agriculture are accustomed to seeing the success of their work within a short time of applying plant protection agents, as may be illustrated by the control of potato beetles, aphis species, *Phytophthora* etc. Even though success may not be attained in certain controls as quickly as for the above, it is at least expected during the course of the same vegetation year, as in the application of seed dressers. When controlling cockchafers, however, it takes at least eighteen months and mostly two and a half years, in other words until the year when the grub begins its main chewing activities, before any perceptible success is achieved, whereas damage inflicted on the leaves of deciduous trees by the cockchafer itself would only interest the forester or the fruit-grower but to a lesser degree, unfortunately, the farmer. This may be one of the chief reasons why the cockchafer control is carried out to such a small extent by agricultural circles and, in fact, only takes place as a rule when large-scale actions are initiated by the authorities or some form of organisation.

It is intended in the remainder of this paper to show that very good results may also be obtained from applications carried out in limited areas. A farm situated on the east-coast of Schleswig-Holstein carried out a large-scale cockchafer control in May 1950 chiefly in favour of the root crop cultivation, in particular potato growing, pursued to a great extent in that region. Following two heavy cockchafer attacks during the evenings of the 10th and 11th of May 1950 and the start of a period of favourable weather on May 16th, notification was given to the neighbouring beekeepers and the control work was commenced in the early hours of May 17th. The woody perennials on which the cockchafer chiefly concentrates its attacks in that area are in so-called thickets which are stocked with several varieties of broad leaved trees mostly 5—7 m high, in addition to which there are fully-developed oaks 7—12 m high, growing at irregular intervals. This thicket was dusted with "E 605" using a small BSE apparatus which is able to reach up to a height of 12 m — or a little over — on calm days. The occurrence of cockchafers was only medium-heavy so that it was chiefly the treee of the first category which were attacked, such as bush-like and fully-developed oaks, wild roses and wild fruit, which were heavily infested, and to a lesser degree trees of the second category, such as hazel, hornbeam, willows etc., whereas trees of the third category, such as blackthorn, were hardly infested at all. The dusting along the thicket was carried out at a uniform rate of 3 km/hour. It was only the heavily infested single bushes and trees that were treated with higher concentrations, so that altogether 25 kg of "E 605" were consumed per km of thicket. It should be mentioned that the main infestation of cockchafers was on the southern side of the thicket running from east to west, whereas that running in the north-south direction was only weakly infested. The reason for selecting this area may be attributed to the fact that at times there was a prevailing light north wind of wind force 1 and the temperature cooled off considerably towards evening.

The results obtained were very good, and after two days there were no living cockchafers to be found and even a later reoccurrence was so slight that it appeared unnecessary to repeat the dusting. Even though countings were not made, it is definitely in favour of the effectiveness of the control that strangers driving past stopped their vehicles to enquire why there were such large masses of dead cockchafers lying around. A ten hectare field section bordered on three sides by thicket and open to the south may serve as an adequate example for the expenditure incurred. This section consists of an average soil for wheat and was at the time cultivated with spring cereals thus offering particularly favourable possibilities for the laying of eggs. The expenditure involved was as follows:

Hiring charge for the apparatus	DM 2
25 kg of "E 605" for 1 km of thicket at DM 1·64	DM 41
wages (including time taken to reach the site), 2 workers per hour	DM 2
	DM 45
8 % interest for 2½ years	DM 9
total for 10 hectares	DM 54

expenditure of DM 5·40 per hectare thus amounts to the value
50 kg of potatoes.

It was not until this year's potato crop was harvested which, in Böhms Mittelfrühe and Immertreu, included two varieties ripening at different periods, that a comprehensive insight into the success of the control could be obtained. When the harvest was gathered in the middle and at the end of October, the

number of attacked tubers was less than 0·1 % although the distance of the crop from the attacked thicket was only between 0 and 200 m, in other words in the area of the heaviest egg deposit. Other potato growing areas of this farm which were only bordered on one side by thicket — which had also been dusted — showed the same results. The check was carried out, however, on a 6·25 hectare area of Böhms Mittelfrühe potatoes growing on the same type of soil but 2 km away from the treated area and in the vicinity of a standard beech wood. At this location the cockchafer infestation did not appear to be heavy enough for dusting and furthermore the small hand duster was not powerful enough so that it was decided not to carry out the control. After the stubble had been turned over in Autumn 1951, large numbers of grubs were found although the field was 250—400 m away from the edge of the wood, in other words outside the area with the heaviest deposit of eggs. At the beginning of August 1952 early chewing damages were detected on the potato tubers and for this reason the harvest was gathered at the beginning of September in order to keep the losses down as much as possible. During the harvesting, it was found that 10—15 % of the tubers, varying slightly at different locations, were chewed to a considerable extent, so that one third had to be assumed as being completely destroyed.

The losses involved may be tabulated as follows:

12·5 % of the tubers out of 24 metric tons per hectare = 3 metric tons, which could only be sold as low value fodder at DM 8, as opposed to the price of DM 12 per 100 kg for eating potatoes — difference = DM 4.

Difference for 3 metric tons =	DM 120
Total loss of 1 metric ton at DM 12 per 100 kg =	DM 120
Extra expenditure incurred by handsorting 20 metric tons (undersized not included) at 20 Pf per 100 kg =	DM 40
loss per hectare =	DM 280

There is no comparison whatsoever between these losses and the control costs of DM 5·40 per hectare. Actually the loss is rather high because the potatoes are from highly bred and elite varieties which are sold at a high price of over DM 5 per 100 kg.

As already mentioned above, the infested potato area was outside the main egg deposit region, with the result that the comparison is of too favourable a nature. This is confirmed by the following observations: parallel to the potatoes but located more towards the wood was a 100 m wide strip of seed beets of which 85 % of the roots had been chewed away; it was merely a plot of solid loam that showed damages amounting to only 40 %. The sugar beet adjoining the seed beets and only 0—200 m away from the wood had been attacked and chewed to 90 % if not completely. The chewing away of large gaps was only prevented by the wet weather which forced the grubs to the surface, as perceptible from the chewing traces. In this way the root tips were not attacked. The yield losses assessed at a minimum of 12 metric tons of beet = DM 720 per hectare, to which the loss of leaves has also to be added, are very great, and it would have been really profitable in this case to have carried out a control of the grubs in the soil. Chewing damage is also expected to be inflicted on the 1953 crops, although this does not apply to the areas already treated. The comparative example of the two potato areas, however, adequately proves the economy of control measures, even though the first perceptible success did not appear until 2½ years following the application.